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SCIENTISTS AND THE GOVERNMENT — DR. CONDON WRITES TO SENATOR HICKENLOOPER

My Dear Senator:

As you know, the House Un-American Activities Committee has released a report making insinuations about my loyalty and charges of untrustworthiness as a scientist in the Government service. I am not concerned about these charges as they affect me personally. These same accusations were made in a newspaper story and in magazine articles written by Congressman Thomas (J. Parnell Thomas, Republican, New Jersey) in June of 1947. Before that time and since then I, like other Government scientists, have been investigated and re-investigated by various agencies of the Government and, so far as I know, have been uniformly cleared. In fact, in July, 1947, after Congressman Thomas' articles appeared, I wrote Congressman Thomas and the members of his committee offering to appear before the committee and to help in any way to answer any questions that they might have concerning me. I received no answer.

That, however, is not the issue that concerns me. As in the case of many other scientists, Government service is not for me merely a means of making a livelihood. It is an opportunity to serve my country and its scientific advance.

Dr. Condon Urges that the Relationship be Clarified

What concerns me is the national weakness and distintegration of our scientific position, if this whole question of proper relations between working scientists and their Government is not fully clarified. It seems to me that this should be done at once. Because of the very special position which atomic energy has in matters of scientific research, I therefore respectfully suggest that your committee give this matter a complete hearing and careful study. I have been trying since I came to the Government to develop and improve the staff of our principal Federal agency, the National Bureau of Standards, for fundamental research in physics, chemistry, mathematics and engineering. The work of the bureau in the field of atomic energy is limited, but important, and the vital character of atomic research to our national security and well-being is such that no part of it can be endangered or imperilled for any cause without great damage to the country.

Frankly, recruiting and keeping scientists in the Government service is not an easy job at best, because of salary limitations, budget difficulties and the notorious amount of administrative detail with which the Federal Government burdens its scientists. But in addition to that there has been a mounting tension of threats of purges, spy-ring exposures, publicity attacks and sudden dismissals without hearings.

All of these make scientists increasingly reluctant to work for the Government. They greatly unsettle their minds, and distract them from the creative efforts which we hope to get from them. Because of these conditions it is becoming increasingly difficult to ask a man to accept a position with any scientific agency of the Government.

This is a matter of concern to your committee because such conditions also apply to the operations directed by the Atomic Energy Commission. Only last week a prominent physicist from the laboratories at Oak Ridge came to see me, and told me that a group of them were going to leave and wanted to come to work for the Bureau of Standards. I could give them no assurances that conditions of work in the Bureau of Standards would be any better than the conditions at Oak Ridge as they were described to me. While this person seemed skeptical at the time I am sure he is this week convinced of the truth of what I said.

An honest reading of the history of the war will show that Germany, Italy and Japan greatly weakened their scientific condition by a series of purges of prominent scientists and a general intimidation and stifling of the spirit of free inquiry among the others. It has been said that after every war the victors adopt the vices of the vanquished. I am sincerely concerned that we are on the point of doing that in the matter of how we deal with scientists in Government.

The issue is larger than appears on the surface because with the growing inter-relationship of science and government there are today very few working scientists (at least in the physical sciences) who are not doing work for the Government or associated with institutions deeply involved in this kind of work. Therefore the whole scientific life of the nation is involved.

I am convinced that your committee, with its established record of careful thorough study of the problems before it, could do the country a great service by studying the whole problem of proper relations of the Government to scientific personnel. Your committee has justly earned the confidence of the nation's scientists, as well as the general public, by reason of its demonstrated understanding of the nature and importance of the scientists' work. I would hope that an investigation by your committee would result in restoring conditions in which men of intelligence will be willing to work for their Government and will not be constantly harassed and harried by irresponsible attacks on their character. It must be remembered that the physicists of this country instituted voluntary security measures in 1939 long before they were able to get their Government to show an interest in atomic energy matters.

In fairness and justice we must put an end to public smears on scientists in and out of Government, and we must also do it in order not to throttle the scientific research which is so important to the material side of our civilization.

If your committee should undertake to make this study I assure you that I will be glad to cooperate in every way, and I am confident that scientists and scientific organizations throughout the nation will provide you with every assistance you may desire.

The attack by the House Un-American Affairs Committee has been widely publicized and, in general, condemned by the press, by professional societies and by distinguished Americans. In our eyes Dr. Condon needs no defense; his reputation is too well established. As an example of the sentiment aroused by the attack we print below a statement by Samuel K. Allison, director of the Institute for Nuclear Studies at the University of Chicago. Resolutions condemning the action of the Thomas Committee have been passed by the American Physical Society, the Emergency Committee of Atomic Scientists, the Atomic Scientists of Chicago, the Federation of American Scientists and others. Representative Chet Holifield of California, who described for the House in July, 1947, the current attempt to discredit Dr. Condon, has again spoken eloquently in his defense.

Readers of the BULLETIN are reminded of articles in its pages by Dr. Condon: "An Appeal to Reason," Vol. I, No. 7, and "Science and International Co-operation," Vol. I, No. 11. Discussions of security and clearance of scientists appear in the article by Harrison S. Brown and Byron Miller, "Loyalty Procedures of the AEC," BULLETIN, Vol. 4, No. 2, and in the report of the committee of the Federation of America Scientists in this issue.

Dr. Allison Speaks In Support of Dr. Condon

As this issue of the BULLETIN goes to press, the latest denunciation by the House Committee on Un-American Activities is a leading feature of the news. A Subcommittee has branded Dr. E. U. Condon, Head of the National Bureau of Standards, as "one of the weakest links in our atomic security," and demanded that W. Averill Harriman, Secretary of Commerce, either call for his resignation or present a statement "setting forth the reasons" why he is kept in office. In a preliminary reply, Mr. W. C. Foster, Undersecretary of Commerce, has pointed out that only recently the loyalty board of the Department considered Dr. Condon's case and found that "no reasonable grounds exist for believing that Dr. Condon is disloyal to the Government of the United States."

The charges brought against Dr. Condon in the Subcommittee's report seem to me, a layman in legal matters, to constitute defamation of character by innuendo. The report contains reckless statements such as the following one concerning the activities of Communists in this country: "They have gotten pretty far, because they got a man as Vice-President of the United States, and he is now their candidate for President." This suggestion that the handful of Communists in this country planned and accomplished the election of Mr. Wallace to the Vice-Presidency is more suitable to a campaign speech than a written committee report.

In the same vein, Dr. Condon by inference is accused of a crime which carries the death penalty if transmission of atomic "secrets" is involved. It is recommended that the attention of the President be called "to the fact that the situation of Dr. Condon is not an isolated one, but that there are other Government officials in strategic positions who are playing Stalin's game to the detriment of the United States."

Nothing in the evidence presented, consisting of items such as alleged association with personnel of the Polish Embassy, conferences with foreign scientists, application for a passport to visit Russia, and membership in the Rockefeller Foundation sponsored American-Soviet Friendship Society could possibly support so grave a charge, and, assuming good faith, one could only conclude that the Subcommittee report was written in a state of hysterical irresponsibility.

To me, having known Dr. Condon for many years, his simple statement that the charges are untrue is sufficient. His alert and critical intelligence, his appreciation of wit and good conversation, lead him to associations with people of similar tastes, with no consideration given to social or class distinctions. All of us have recently met and enjoyed conversation and discussion with foreign scientists visiting us. In my experiences, it has been invariably true that the visitor realized that certain questions could not be answered, and carefully avoided embarrassing me by asking them.

The Japanese were amateurs at supervising the lives of their citizens. There the terror consisted in denunciation of persons for "dangerous thoughts." We have, in addition, dangerous acquaintances and dangerous dinner parties.

Treason is a crime abhorrent to every one. It is specially reprehensible in a democracy where there can be criticism of the government by those who believe its policies are wrong, and public opposition may be conducted without fear of reprisal or question of loyalty. Charges that such a crime has been committed should not be made in the malicious manner we are now witnessing.

Dr. Condon should obtain legal counsel and under the law, seek what redress he may for the harm that has been done him.

—Samuel K. Allison

THE PHYSICIST AND THE FUTURE DEVELOPMENT OF ATOMIC ENERGY

Robert F. Bacher

In a speech delivered to members of the American Physical Society in New York City on January 30, Dr. Bacher discussed certain aspects of the atomic energy program that are currently of greatest concern to the country's physicists. Dr. Bacher was formerly Professor of Physics at Cornell University and associate director of the Los Alamos Laboratory. He is now a member of the U.S. Atomic Energy Commission.

The development of atomic energy has shown that one of the frontiers of science is very closely tied to the destiny of mankind. The problems of the structure of matter are now a part of international relations. This connection between research and world and national affairs has brought a new sense of responsibility to the scientist and because of the nature of nuclear energy, most particularly to the physicist. It is a radically new experience.

Today, most physicists feel very deeply this responsibility and are searching for a pattern of conduct. Such a pattern will probably be developed only by experience. The realization of its need and attempts at formulation are having a profound influence upon physicists.

This same close relation between the frontiers of science and world affairs has brought many problems to the scientists and most particularly to the physicist in practicing his profession. One of the fundamental subjects, nuclear physics, has within it an area, fission physics, which is the base upon which the whole atomic energy program is built. With major parts of this work withheld from general dissemination, grave problems arise on one of our most important scientific frontiers.

Scientific Freedom In Time of War

Freedom of investigation and discussion has been the cornerstone of scientific progress. Continued scientific progress is today not only important to the scientists, but in many fields it is necessary to the long-range success of the atomic energy development. Since the withholding of information in certain fields, pending certain international arrangements, is a declared national policy written into law, the scientist is confronted with major problems in following his profession. These problems are an immediate concern of the Atomic Energy Commission since progress in the related fundamental science is vital to the long-range success of the Atomic Energy Project.

Entirely apart from these objective considerations, many of us have some deep feelings on scientific freedom. These stem, no doubt, from both our scientific training and our upbringing in a democratic country.

From 1940 until late in 1945 the major effort of scientists was directed toward either war research or the training of members of the Armed Forces. The tempo of this work was ever increasing until the end of the war. Scientific work in the many fields of physics, chemistry, biology, medicine, and engineering made major contributions to the war effort. During this period most of the traditions of free and open research in the sciences were laid aside in favor of the immediate goal of something which would be useful in the war, because it was realized that unless we were victorious, academic freedom was doomed perhaps for generations. War research inevitably carried with it restrictions on the exchange of information and an entirely new set of values on what research was "interesting." Research was considered interesting only if it seemed to bear upon the problems which were necessary to solve for the war effort.

At the end of the war, large numbers of the scientists who had been engaged in the war work returned to their normal pre-war pursuits. We were eager to get back to a free and unrestricted scientific atmosphere. We were all tired of working at classified projects. Moreover, most of us felt that many of the subjects considered classified during the war would no longer need to be kept as such. Indeed, many articles on subjects which had not been mentioned aloud for years soon started to appear. Electronic developments in radar and the proximity fuse, nuclear physics and particularly neutron physics, and a host of other subjects began to appear in scientific journals.

Declassification Depended Upon International Control

In the Atomic Energy Project, a committee of scientists was set up to recommend policies of declassification. This Committee, which was headed by Dr. Richard Tolman of the California Institute of Technology, first met in the fall of 1945. At that time the Committee set apart a considerable number of scientific and technical subjects which it felt could be immediately declassified without prejudice to any vital secrets of the Atomic Energy Project. The subjects recommended for declassification included certain sections of basic physics, chemistry, metallurgy, biology, and certain technological developments, many of which have today appeared in various scientific and technical journals.

In addition, the Committee considered that there were other questions more closely connected with the production and use of fissionable material which must be reserved for later consideration. In particular, there was a further group of subjects clearly connected with the development of atomic weapons which it was felt could not be considered for possible declassification until a satisfactory international arrangement for the control of atomic energy had been developed. At that time, most scientists felt that there would soon be progress toward international understanding, and we all shared some hope that the policy of declassification was

an interim policy which would be largely unnecessary upon the establishment of suitable international arrangements.

In the summer of 1946, the United States advanced a proposal for the international control of atomic energy in the first meeting of the United Nations Atomic Energy Commission. These proposals have been debated pro and con for something over a year and a half. With some minor exceptions, they have met with approval by the majority of the countries which have been, or are, members of that Commission. Unfortunately, a small minority has held a quite different view on the fundamental nature of a proposal for the control of atomic energy. This difference is not just a minor one but goes so deep that it would be naive to think that an agreement is just around the corner.

While every effort should be made to attempt to resolve these difficulties, it would certainly be unrealistic at this time for us to continue to regard the subjects of declassification and the prosecution of unclassified and classified research as ones which will soon be resolved in the light of a far reaching international agreement. Whatever policy is adopted now for unrestricted research and the continuation of research and development in the classified areas must be more than just an interim policy.

Relation of Classified To Unclassified Work

Since research and development in many diverse subjects are vital to progress in the Atomic Energy Project, a considerable amount of thought in the United States Atomic Energy Commission has been directed toward the relation between classified and unclassified work. I should like to tell you a few of our conclusions this evening.

The Atomic Energy Act of 1946 states: "Research and experimentation in the field of nuclear chain reaction have attained the stage at which the release of atomic energy on a large scale is practical. The significance of the atomic bomb for military purposes is evident. The effect of the use of atomic energy for civilian purposes upon the social, economic, and political structures of today cannot now be determined. It is a field in which unknown factors are involved. Therefore, any legislation will necessarily be subject to revision from time to time. It is reasonable to anticipate, however, that tapping this new source of energy will cause profound changes in our present way of life. Accordingly, it is hereby declared to be the policy of the people of the United States that, subject at all times to the paramount objective of assuring the common defense and security, the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace."

The general policy stated here is set forth in more detail in other parts of the Act. On the one hand, the Atomic Energy Commission is charged with the responsibility for the production of fissionable material and for the development and production of atomic weapons. On the other hand, it is asked to promote vigorously the peaceful uses of atomic energy and the dissemination of scientific and technical information. I believe that most of you will agree that it is very difficult to pursue at the same time both objectives with maximum effectiveness. This, nevertheless, is the job.

For the development and production of fissionable materials and weapons, it is now necessary, and it will probably continue to be necessary, to maintain strict security and secrecy. Such security safeguards will, necessarily, have to carry over into certain of the peacetime uses of atomic energy. For example, the development of nuclear reactors is closely tied to the production of fissionable material and will need to be classified. On the other hand, many of the uses of these reactors are unclassified. Radioactive isotopes produced in the Oak Ridge reactor are now distributed in this country and to foreign countries, and efforts are being made to promote their use in a wide range of scientific and technical researches. Many fundamental physical and chemical experiments have been made possible by the strong neutron sources which these reactors provide. Results of numerous such experiments have appeared in scientific journals.

The development of atomic energy depends upon the training of young men in the sciences and in engineering and this training is usually carried on in universities in close association with basic research. The development of atomic energy thus depends doubly upon the well-being of basic scientific research. First, we must have a solid foundation in nuclear science on which to build the enormous technical development of atomic energy. Our knowledge of the fundamentals of nuclear structure is little more advanced today than it was ten years ago. Secondly, it has in the past been largely through the prosecution of such research that new men were trained in the field of fundamental sciences.

The Work of the AEC

Before going further with a few remarks about how we hope to meet some of these difficulties, it would perhaps be well to make a very brief outline of the work of the Atomic Energy Commission as it looks today. This work can be broken into four main categories:

1. **The production of fissionable materials.**—As you know, two fissionable materials have been produced in quantity: Uranium 235 by isotope separation, and plutonium 239 as a product of nuclear reactors. The production of each of these materials is a major industrial process and like other industrial operations is constantly subject to improvements. The production of plutonium is particularly related to the problem of nuclear reactors which are themselves of interest as producers of heat and electrical energy as well as producers of fissionable material and neutrons. The production of fissionable material depends upon the maximum utilization of the raw material and also upon the development of new sources of raw materials.

2. **The development, production, and test of atomic weapons.**—This work is clearly related to the production of fissionable material. Development and production of atomic weapons, which is a clearly assigned responsibility of the Atomic Energy Commission, is carried on at the Los Alamos Laboratory in New Mexico. Since it would make little sense to carry on development work without provision for test, a proving ground for atomic weapons has recently been established at Eniwetok in the Pacific.

3. **Development of nuclear reactors.**—Nuclear reactors are producers of fissionable material, but they are also producers of heat and may in the future become producers of electrical energy. They are today producing

radioactive isotopes on an ever increasing scale for a wide variety of researches. The development of nuclear reactors in the post war era is just beginning and we may expect major advances in the coming years. The practical production of electrical power from nuclear reactors will almost surely come. There will probably be a small-scale production within two years. While there are many difficulties to be overcome, we look forward to the operation of a large-scale reactor for the practical production of electrical power within, say, ten years.

4. Basic research.—It is clear that we must have a better understanding of nature on which to build the structure of an atomic energy technology. Such an understanding is needed in many sciences, including chemistry, metallurgy, and biology where the Atomic Energy Project has many times found need for new fundamental knowledge from which to make further technical advances. While no one can point to basic science work and say that a particular experiment satisfactorily concluded will inevitably lead to new technical developments, we are all sure that a sound, fundamental base is necessary for any long-range technical development.

How can this far reaching program which includes both highly classified and unrestricted work be carried out with maximum effectiveness? For the production of fissionable materials and the development and production of weapons, it is clear that definite security limitations are necessary. The development of nuclear reactors, while generally classified because of its relation to the production of fissionable material, will involve considerable work of an unclassified nature. For the pursuit of basic research, the tradition of openness and freedom is a sound one and will certainly lead to the best results.

While the members and staff of the Atomic Energy Commission have considered rather thoroughly the various ways of pursuing this program, we make no pretense of having arrived at a complete solution. We do feel that in the last year we have learned a bit and now see a few ways in which a problem can be attacked.

We have been led to the adoption of certain policies. While we recognize that some exceptions may need to be made, we believe that these policies can usually be followed. We believe that basic research in the sciences related to atomic energy should be centered in the universities and in certain unrestricted areas of the Commission-owned laboratories. Such a policy will be best for the promotion of fundamental research in the various fields of science and will, at the same time, provide a maximum stimulation in the training of young students.

The Basic Research and Fellowship Programs

The Commission is actively supporting such a program of basic research both by individual arrangements with universities and by the support of several regional laboratories to which a large number of universities in various parts of the country have access. The removal of restriction from various areas in these Commission-owned laboratories has already been started. The Office of Naval Research has since the war supported basic research in many fields and particularly in the field of nuclear physics. Arrangements are being made by the Commission to support jointly with that office the research which is related to nuclear physics and the development of atomic energy including certain biological and medical research. The early establishment of a National Science Foundation would be a great help in the encouragement of scientific work in these fields.

The decision has recently been made by the Commission to establish a considerable number of fellowships in the physical and in the biological and medical sciences and in the new field of health physics. These fellowships, which will be administered through the National Research Council, should help in the scientific training of predoctoral and post-doctoral students in these fields. They will provide for training and research at universities and also at the several national laboratories.

Special Laboratories For Classified Research

The Commission would like to avoid as far as possible establishment of classified research at individual universities. We believe that it is wise to carry on such work primarily within the confines of laboratories established for that purpose. Now, it is quite clear that certain exceptions will have to be made to this rule where the particular qualifications of some individual or of some laboratory make it highly desirable that a certain piece of work should be carried on at that spot.

The work upon the development of weapons and on the production of fissionable materials and the development of reactors is classified, and it seems unlikely that it will be conducted in open laboratories and factories in the near future. This classified work is largely centered in the installations at Los Alamos, Oak Ridge, Hanford, and the Argonne Laboratory near Chicago.

The weapons work is the responsibility of the Los Alamos installation. Production of fissionable material is carried on at Oak Ridge and Hanford, Washington. The development of reactors has been carried on at the Argonne Laboratory, at Oak Ridge, at Schenectady, and with some work also at Los Alamos. The Commission has recently taken the decision to consolidate most of the work on reactor development at the Argonne Laboratory. This move will require some time to carry out, but it has become clear that reactor development can go forward with the greatest acceleration if it is the main responsibility of a single laboratory.

Although there is some classified work at Berkeley, at the Brookhaven Laboratory, and at several other installations, it is our hope that most of the classified work can be carried on at a relatively small number of central locations. We believe that such a policy leads to better security. Some deviations from this policy will probably be necessary in obtaining an increased participation by industry in the Atomic Energy Project.

We should like to promote basic science related to the atomic energy developments under conditions where it is free from any process of declassification and where there will be opportunity for the training of new students. Now, it is clear that in the laboratories where classified studies are undertaken, discoveries will frequently be made which can be declassified. Inevitably this process of declassification will require extra time in the dissemination of scientific results. The avoidance of such procedure by the location of much of basic science work in unclassified areas within the Commission-owned laboratories will not only be more natural but will lead to a more rapid development.

During the past year several requests have been made to the Commission for an exact demarcation between classified and unclassified information. Some people have construed the Atomic Energy Act to mean that all information touching on nuclear physics is classified until declassified. The Commission does not believe that all nuclear physics is or should be classified. It is not possible, however, to offer a flat guarantee to anyone that, in pursuing a certain course of investigation, he will not come upon information which should be restricted under the terms of the Act. For work in most areas which do not touch upon fissionable materials or other special products of the Atomic Energy Project, the probability is great that classified information will be avoided. It is just this conviction which prompts us to place emphasis upon the creation of unclassified areas in the national laboratories and upon the pursuit of unclassified research in the universities.

Clearance Procedures Adopted by the AEC

Under the Atomic Energy Act, access to restricted data ordinarily will not be granted to any individual "until the Federal Bureau of Investigation shall have made an investigation and report to the Commission on the character, associations, and loyalty of such individual and the Commission shall have determined that permitting such person to have access to restricted data will not endanger the common defense or security." It is upon this statement of the McMahon Act, and upon other statements of that Act which are somewhat more detailed, that the clearance policies of the Atomic Energy Commission are based.

During the past year there has been considerable hardship occasioned by the clearance procedure required by the new law. The tremendous amount of work to be done by the Federal Bureau of Investigation in the investigation of all project personnel required by law has led to many unavoidable but quite serious and costly delays. The Commission believes that the orderly process of clearance will in the future be much faster.

For scientists in particular, the question of clearance raises definite problems. In any project involving restricted data, the scientists are usually the ones who must have those data. Moreover, a significant fraction of scientists in certain fields are at present associated to some degree with restricted information. Under these circumstances, failure of clearance for an individual may exclude many possibilities for employment and may, unfortunately, influence an employer not to employ that person on a completely unclassified project. Yet, it is very likely that there will be some who do not meet the requirements for clearance stated in the Atomic Energy Act.

Under these circumstances, the greatest care must be taken to avoid injustice and to provide an opportunity for any person to be heard and to learn the reasons for the action in case of denial of clearance. The Commission has recently invited a group of distinguished citizens under the chairmanship of Owen J. Roberts, former Associate Justice of the United States Supreme Court, to act as a Board of Review. This board will consider both general and specific policies. The Commission feels that the work of this Board will be an important step in the difficult problem of carrying on classified projects.

In conclusion, I would like to say a little about how the work of the Commission has been getting ahead during the past year. Several installations which were very severely hit by the withdrawal of scientists and engineers to return to their prewar jobs have recovered their balance and are producing valuable new work.

A Summary of Progress At the AEC Laboratories

At the Los Alamos Laboratory, there has been significant new work on the development of weapons. Laboratory personnel are now engaged in work in connection with the newly established proving ground in the Pacific. Major construction has been undertaken to establish permanent buildings and houses at Los Alamos in place of the temporary facilities of the war.

In the production of fissionable material process improvement was continued with renewed vigor. At Hanford, where the nuclear reactors are located which produce plutonium, there is now a major construction program. It is in the field of the production of fissionable materials and the supporting activities that the Commission spends the greater part of its funds.

The development of nuclear reactors of new and advanced types has been pursued. The Commission believes that the success of the Atomic Energy Project depends upon this work. As I have said, the decision has recently been taken to centralize most of the reactor development work at the Argonne Laboratory. A new site for this laboratory is being acquired and in the spring construction will start upon a new reactor and upon several permanent laboratory buildings. At Los Alamos, a research reactor which operates with fast neutrons has been completed. At Schenectady, the Atomic Energy Project occupies temporary quarters while the new Knolls Atomic Power Laboratory is under construction. At Brookhaven, ground was broken last summer for a reactor for general research purposes.

In research and development there have been many new contributions. At Berkeley, the big synchro-cyclotron is in operation and the properties of high energy neutrons and the results of nuclear spallation are being investigated. At Oak Ridge, there have been numerous additions to neutron physics. The Commission wishes to support there a vigorous National laboratory with basic research in physics, chemistry, biology, and health physics as well as applied research. The radioisotopes and stable isotopes which are playing an important role in so many different fields are produced there. At Brookhaven, there has been a major start in getting a new research laboratory into operation. The work at most of the laboratories covers many scientific fields. In particular, biological and medical work is being established under the guidance of a newly established Advisory Committee for Biology and Medicine on a much broader base.

In looking back over the first year of the Commission's work, we see that some of the efforts to change this gigantic project to a peacetime development with many objectives are beginning to show results. We have called upon many for help during this past year and the unselfish response has been very heartening. The General Advisory Committee, in particular, has been invaluable in this work. We believe that the rate of advance increased during 1947 and are confident that it will be still further increased during the coming year.

THE WARTIME ACTIVITIES OF GERMAN SCIENTISTS

Max von Laue

The following communication has been received from Dr. von Laue, co-director of the Kaiser Wilhelm Institute fuer Physik (Max Planck Institute). Dr. von Laue is also engaged in the reorganization of the Physikalisch-technische Reichsanstalt. A reply from Dr. Morrison and an editorial comment follow.

In the BULLETIN OF THE ATOMIC SCIENTISTS for December 1947 (p. 365) Philip Morrison, in a review of Goudsmit's book *Alsos*, writes as follows:

"The documents cited in *Alsos* prove amply, that no different from their Allied counterparts, the German scientists worked for the military as best their circumstances allowed. But the difference, which it will be never possible to forgive, is that they worked for the cause of Himmler and Auschwitz, for the burners of books and the takers of hostages. The community of science will be long delayed in welcoming the armorers of the Nazis, even if their work was not successful. Men were able to remain aloof from the German war efforts, and brave and good men like Laue and Gentner could resist the Nazis even in the sphere of science. That is a story *Alsos* does not fully tell."

At the time of writing we have not yet seen the book itself. One concludes however from the above quotation that it is the reviewer who explicitly puts forward the monstrous suggestion that German scientists as a body worked for Himmler and Auschwitz. How far Morrison has suffered personally through both or either is unknown to us. We do know that Goudsmit lost not only father and mother, but many near relatives as well, in Auschwitz and other concentration camps. We realize fully what unutterable pain the mere word Auschwitz must always evoke in him. But for that very reason we can recognize neither him, nor his reviewer Morrison, as capable of an unbiased judgment of the particular circumstances of the present case. Accordingly a few words in protest may be allowed us here.

Ever since war between civilized states relapsed once more into the old barbaric "total" war between peoples, it has been no easy matter for an isolated citizen of a warring nation to withdraw himself altogether from war service; indeed, it is relatively unimportant whether he puts his heart into such war service, or whether he is opposed to the methods of his government, or even whether he would depose it. If one or other among the German scientists found it possible during the war to avoid being drawn with his work into the maelstrom, it is not allowable to conclude that it was so for all.

The directors of the larger research institutes in particular were under the absolute necessity of putting the facilities of their institutes at least partially and formally at the service of the war effort. Open refusal on their part, immediately classable as "sabotage", would have led inexorably to castastrophic consequences to themselves. On the other hand, an (often fictitious) compliance with the demands of the armed forces had advantages which our opponents should recognize as legitimate. In particular one could in this way shield a quite considerable number of the younger specialists from a much more direct mobilization for war; and by this and several other means preserve throughout the war years the foundation on which now, *after* the war, we seek to build afresh.

Sometimes too the possibility arose of protecting political suspects from concentration camps or worse, by assigning them research work of more or less "military importance". Our severer critics might perhaps inquire about such cases among non-Aryan Germans (there were a few such in Germany even during the war). Or do they wish to declaim even in these cases about "armorers of Himmler and Auschwitz"?

Nevertheless: whosoever put his institute in this fashion at the disposal of the military authorities, put himself in an ambiguous position. That is the particular curse of such a time: and it visited not Germans only. Thus a foreign colleague, who during the occupation of his fatherland by Hitler's troops had been particularly active in the underground movement, told me recently that the double dealing to which he was forced thereby lays him open even yet among many of his compatriots to the suspicion of collaboration. This example illustrates how careful one must be in passing judgment on events which took place under a tyranny.

Part of the answer to the question which asks what German scientists were actually about during the war is given in the 50-odd volumes of the *Fiat* Reviews of German Science 1939-46, now in course of publication. There one may find, not perhaps world shaking results, but h o n e s t, solid scientific investigation, following steadily in the steps of the preceding peacetime research, now once more resumed. Admittedly, the scientific journals lapsed, one after another, towards the end of the war; but not for lack of work submitted for publication, but because of paper shortages, bomb damage to printing houses, and other economic strictures. In the case of the *Zeitschrift für Physik*, for instance, where I know the circumstances at first hand, there were 60 manuscripts awaiting publication at the end of the war; since when the editors could have accepted 86 more, which still deal, to a considerable extent, with work carried out during the war years. But nothing in their contents points to that fact; and they have verily nothing whatsoever to do with Himmler and Auschwitz.

What do the "Atomic Scientists" aim at in their BULLETIN? So far as I understand it, the attainment of a durable peace. But that high aim is ill served by articles such as the review from which we have quoted; they keep alive hate, on the elimination of which *everything* hinges. We recommend as the foundation of every utterance of peace politics, in great and small things alike, the words which Sophocles puts in the mouth of Antigone, citizeness of a victorious state:"To league with love not hatred was I born".

A Reply to Dr. von Laue

Philip Morrison

It is with regret that I must take issue with the moving statement of Professor von Laue, and with his implied defense of those scientists who worked for the Waffenamt, the Wehrmacht, and the Luftwaffe. I said in the review of which he writes that these men worked, not for Himmler, but for Himmler's cause, the victory of a National Socialist Germany. Where this is true, I feel that my indictment must still stand. Where laboratory work was in fact a cover for underground activity, where it was meant chiefly to save the enemies of the Nazis from imprisonment, or even when it was carried out in a way remote from the war, by men—perhaps they were the majority of *Zeitschrift* contributors—who tried "to remain aloof from from the German war effort", no such criticism applies, nor was it stated or intended. I do not believe that there is an unwarranted subtlety in such a distinction.

One point remains at issue. What of those men, "directors of the larger research institutes in particular", says Professor von Laue, who complied with the requests of the Nazi armed forces? Perhaps their compliance was in some cases fictitious: here too there would be no issue. But many of the most able and distinguished men of German science, moved doubtless by sentiments of national loyalty, by traditional response to the authority over them, and by simple fear, worked for the advantage of the Nazi state. These men *were* in fact the armorers of the Nazis. Professor von Laue, as the world knows and admires, was not among them. It is not for the reviewer to judge how great was their peril; it is certainly not for him to imply that he could have been braver or wiser than they. But it was sentiments like theirs, weakness like theirs, and fear like theirs which helped bring Germans for a decade to be the slaves of an inhuman tyranny, which has wrecked Europe, and in its day attacked the very name of culture. Are we to forget the tragic failure of those German men of learning?

Professor von Laue, whose outspoken opposition under Hitler was a token of his wisdom and integrity, begins his piece with a most uncharacteristic reference *ad hominem*. He wonders whether I suffered personally through Himmler and Auschwitz. I did not. But I do not see that it is fair or relevant to ask. I am of the opinion that it is not Professor Goudsmit who cannot be unbiased, not he who most surely should feel an unutterable pain when the word Auschwitz is mentioned, but many a famous German physicist in Göttingen today, many a man of insight and of responsibility, who could live for a decade in the Third Reich, and never once risk his position of comfort and authority in real opposition to the men who could build that infamous place of death.

Comment by the Editor

This issue of the BULLETIN contains a letter by Professor Max von Laue, protesting some remarks on German scientists made by Philip Morrison in the December issue. Dr. von Laue, the discoverer of X-ray diffraction by crystals, is not merely a distinguished scientist; he is one of the German scholars who stood for the spirit of humanity and the integrity of science throughout the dark years of the Hitler rule. He barred the door of the Berlin Academy of Sciences to the Nazi stooge, Johannes Stark, and has maintained his friendship with Einstein and other German exiles when this was considered tantamount to national treason. He clearly saw the guilt loaded upon the German people by its rulers; and the inevitability of retribution. Dr. von Laue has the right to a respectful hearing by American scientists, particularly those who have made understanding between nations their paramount objective.

Dr. Morrison makes it clear that he did not intend to indict the German scientists as a body. Nevertheless, considerable difference remains between his qualified readiness to extend the hand of friendship to many and von Laue's feeling of solidarity with the majority of his colleagues.

Von Laue would like to see the notorious Nazis among the scientists, or their friends, punished or at least morally isolated, and, at the same time, professional recognition and human rights restored to all those who merely carried on as best they could under the tyrannical regime. Morrison, on the other hand, is inclined to include many of these "average" German physicists, chemists, or engineers under the "not unwilling armorers of the Nazis." Even more pointedly, his criticism applies to some men of great prominence in science, whose apparently unreserved collaboration with the criminals in power undoubtedly helped to subdue the qualms of many a rank-and-file German scientist.

If things are allowed to take their course, the international scientific community will undoubtedly "long delay"—to use Morrison's expression—the welcoming of German scientists, even purged of notorious Nazis, into international organizations and conferences. After the war of 1914-1918, several years had to elapse before the bitterness between scientists and intellectuals on both sides died down; it will take many more years after the Second World War for time to heal the much deeper wounds.

German Recovery Must be Part of a Stable World Order

But should we let time be the only healer? There are some who think that the Second World War would not have occurred if the Germans had been given a fuller understanding of, and sterner punishment for, their collective guilt in the first one. Is it, however, not more deeply true that the decisive cause of the Second World War was not the failure of the victors to confront Germany, when she came out of the stupor of defeat, with a world stably organized for peace instead of a happy hunting ground of national rivalries and conflicts?

Whatever the truth about 1918, something more constructive than disarmament and punishment of aggressor nations is required now to forestall fresh disasters. Our present predicament flows in part from the attitude of our political leaders who have approached victory with the one idea of "making it stick, this time,"

and of "avoiding the mistakes of 1918." They believed that if Germany were denied opportunity to commit aggression again, then peace would be assured. As the post-war problems of peace have accumulated, the idea has been extended to cover other suspect nations, including the Soviet Union. But the problem is much more fundamental—and much more pressing than in 1918. Participation of the United States in the League of Nations could conceivably have assured stable peace then. The participation of the United States in the United Nations obviously is not enough for this purpose now.

Scientists Share Responsibility to Create World Community

The overwhelming need is for a positive solution on a grand scale, for the creation of a world community of nations, without which the international community of scientists cannot exist any more than free science can survive under a totalitarian dictatorship. By their indifference, by their unreadiness to act and, if need be, suffer personal inconvenience and persecution for the sake of this community, by their meek drift with the current toward ever stronger nationalism and militarism, scientists everywhere are loading themselves with a guilt of omission not unlike that with which we now charge the rank-and-file German scientists who failed to resist the disastrous policies of their government. We cannot and should not justify the supine failure of German scientists to accept their obligations to humanity and free science; but rather than carry the grudge against them until time wears it down, should we not better take this failure as a lesson and warning to ourselves?

If we continue to take for granted a world system in which individuals are subservient to nations, and nations are under no law, then retribution meted out to individual citizens, guilty, half-guilty, or innocent, for the criminal acts of the nation, remains a logical thing, and constitutes one of the few available—albeit notoriously ineffective—instruments of international justice and restraint. But if we are agreed that the maintenance of this system means disaster, if we have—as we pretend—dedicated ourselves to the building of a new order in which no nation is beyond the law, and no individual can be forced to serve the aggressive intents of his national authorities, then the prolongation of suspicion merely helps to perpetuate international anarchy. Discrimination against the half-willing or unwilling accessories to previous aggressions (as distinct from punishment of those guilty of individual crimes), renders more difficult the common task of all scientists—Russian, German, American or British alike—to prevent the present divisive system from leading mankind into catastrophes much more disastrous than the World Wars of 1914 and 1939.

—E. R.

BOOKS

DIE GESCHICHTE DER ATOMBOMBE. By Hans Thirring. Vienna, 1946. "Neues Osterreich" Zeitungs— und Verlagsgesellschaft.

There is at present certainly no dearth of popular books on the atomic bomb. Most of the books which have appeared so far give very elementary accounts of the basic phenomena. A valuable addition to this collection is a new book by Professor Thirring, professor of theoretical physics at the University of Vienna, which was published in 1946 in Austria, but did not come over the ocean until recently. It contains an introduction to nuclear physics, and a stirring account of the technical developments in this country which culminated in the dropping of the first atomic bomb.

This book is distinguished from most of the other books in this field, in that it is addressed to a somewhat higher intellectual level than its predecessors and is probably most appropriate for people who have had some scientific training in fields other than physics. For these readers, the so-called educated laymen, it is probably by far the best yet written on this subject. It is a great pleasure to read, even for someone who knows the story already, because it is written with such lucidity and with such tension. One feels as if one were reading a detective story and is tempted to read the whole book from beginning to end without interruption.

The introduction to the foundation of atomic and nuclear physics is an outstanding work of simple and concise formulation. The development of the bomb, its problems and its technical difficulties, are discussed very much along the lines of the Smythe report. It is astounding how vivid the difficult phases are when described by a man who learned of these events only by reading the Smythe report and the daily newspapers. One chapter is devoted to the utilization of light elements for nuclear explosions and discusses the great difficulties which would have to be overcome before such a possibility could be realized.

A few chapters have some interesting political significance. Professor Thirring strongly takes the American side in political questions and defends to the limit all decisions and actions of the American Government. He explains and approves the official reasons given for the application of the bombs in Japan and also quotes and discusses very favorably the attempts of the U. S. Government to get international control of atomic energy. The Lilienthal plan is not included, since the book was written before its publication.

The author criticizes very strongly any over-optimistic evaluation of the possibilities of atomic power. The new discoveries supply no reason to stop the development of other power sources, such as water power, which plays a great role in Austria. It seems from his emphasis on this point that some circles in Europe have contemplated halting the expansion of water power in expectation of early atomic power sources. He also spikes a rumor which seems to have been current in Europe that the U. S. A. was able to construct the bomb only after capture of the discoveries made by the German scientists during the war.

It is hoped that this book will be translated into English. It will be appreciated by many people who find the present literature too popularized and the Smythe report too dry to digest.

—V. F. Weisskopf

OUR TASK IN GERMANY

Samuel A. Goudsmit

Dr. Goudsmit is deeply convinced that only a more positive concern on the part of American scientists can encourage a belief in democracy among their German colleagues. These remarks were written independently of the discussion on pages 103-105 that stems from a review of ALSOS, Dr. Goudsmit's story of German Wartime Science. Formerly a member of the Physics Departments at the University of Michigan and at Northwestern, Dr. Goudsmit has recently joined the staff of the Brookhaven National Laboratory.

Science has always benefited by world-wide cooperation. The work of each individual scientist depends upon knowing what others in his field have done or are doing. This pooling of knowledge has made research workers acutely aware of the futility of national barriers in the fields of science. It may well serve as an example of true international cooperation, based on a realistic approach to the advantages for all and not on idealistic pipe dreams. The continuous exchange of scientific information, though inspired by necessity, provides also a basis for better understanding and real friendship among men of science.

It is with this in mind that we must consider renewing our relations with German scientists. It would be understandable if many among us were reluctant to converse with our German colleagues again as if nothing had happened. They supported the Hitler crime against humanity, or at least did not do much against it at the earlier times when opposition was still possible. Many of these Germans did not see the evils of a totalitarian regime until its dogmas interfered with the teachings of science. They believe that they did their full share by merely having resisted this encroachment in their domain of learning.

The attitude of most of our colleagues over here is, however, not due to considerations of this kind, but to extreme indifference. While this avoids the necessity of deciding how to confront former enemies, it is a dangerous indication of complacency.

It is true that pure science in Germany under Hitler declined rapidly in quality and quantity and has little to offer compared to the leading role it played in the 1920's. In fact the few worthwhile contributions came from scientists already prominent in that pre-Hitler period; almost no new talent was added under the Nazi regime. Though we can gain almost nothing from German scientific work and only little from a few technological developments, an attitude of indifference on our part will be detrimental in the long run.

The United States' foreign policy should determine just how to deal with the problem of German science and scientists. In a democracy the foreign policy is meant to reflect the will of the people and thus American scientists should inspire their Government's handling of science in occupied territories. Our present unconcern has certainly no constructive influence.

The Kind of Program That Must Be Developed

As scientists we could help create a constructive policy of promoting democratic ideals among our German colleagues.

Due to our apathy the situation in German scientific circles seems to be deteriorating rapidly. It is almost impossible to obtain factual and reliable information from there, which in itself is a bad sign. Casual visitors, official or unofficial, cannot penetrate beneath the surface except for those few who knew the German colleagues well before the war. Communication is slow and inadequate. But the few facts that reach us paint a gloomy picture. Several foes of democracy or advocates of revenge have regained prominent educational positions. "Those who would have dared to speak up are silent forever. Those who still can speak up are again afraid to open their mouths," a letter informs me.

It is our duty to do whatever we can to improve this situation. What is obviously needed is a more active interest on the part of our scientists in the events that take place in German academic circles. Only then can we prevent, perhaps, a return to power of the undesirables.

Though it is too readily believed that Hitler was the only advocate of totalitarian excesses, it is nevertheless a fact that he had strong supporters among our German colleagues. It is, of course, impossible with a few exceptions, to decide who were active Nazis and who were not. But fortunately there are many German scientists with some understanding of the meaning of democracy and its value. Moreover the problem of de-Nazification if soluble at all, is entirely an internal German affair.

We need a positive program to guide events in German scientific circles in a more favorable direction. This means that we must morally support those German colleagues in whose integrity we have confidence. There are many of them. We do not have to agree with all their opinions and should make allowances for the disturbing circumstances under which they have lived and are still living. We must again communicate with them as in the days before Hitler. The exchange of scientific literature, now practically at a standstill due to our indifference, should be actively promoted. German scientific research should again be helped by grants and supplies. By thus supporting the right persons, institutions or programs we might finally create an atmosphere of mutual understanding, beneficial to the spread of democratic ideals and practices.

We cannot wait much longer. Many foes of the Nazi regime have been bitterly disappointed by postwar events in Germany. Former Nazis and Communists are quick at makink use of this feeling of discontent. If we as American scientists take a greater interest in this problem, the proper U.S. Government agencies may adopt a policy of action more in line with our recommendations.

THE WORK OF THE HARWELL ESTABLISHMENT

H. W. B. Skinner

The accomplishments and plans of the British Atomic Energy Establishment at Harwell, near Didcot, Berkshire, were described by Dr. Skinner in a lecture delivered before the British Atomic Scientists' Association, September 20, 1947. Dr. Skinner's own efforts have played an important part in the successful initiation of the Harwell project.

On October 28, 1945, the Government authorized the foundation of a Research Establishment at Harwell to carry out research and development in atomic energy. The Harwell Airfield was handed over on January 1, 1946. There were a number of hangars, barrack blocks and other buildings which it was proposed to convert into laboratories, also a certain amount of residential accommodation, in the form of the aerodrome messes, officers and married men's quarters, etc.

The Task of Assembling Equipment and Staff

The contractors appointed by the Ministry of Works began work in April 1946, but it took some months before work was begun on any large scale. We have thus had less than eighteen months in which to get going. We have now one major piece of equipment working and several others as well on the way. We have a number of buildings already converted into permanent laboratories as well as a considerable amount of temporary laboratory accommodation. We have considerable workshop and drawing office staffs. We have completed two sites of prefabricated houses, and two other housing sites, at Abingdon and Wantage, are well in hand. Although to one watching day-by-day, things have sometimes seemed to be moving slowly, I think there is no doubt that the over-all picture shows very considerable progress in the time.

The terms of reference of the Establishment are to carry out work on research and development in atomic energy. This was interpreted as work primarily aimed towards the development of atomic power, and, as a very important secondary objective, towards the provision of radioactive tracers for biological and other research. The task of highest priority was therefore the provision of atomic piles for experimental work and for the manufacture of tracers. Since all aspects of this work have to be covered, from building the pile to such questions as safety of operation, from manufacture of tracers in the pile to their separation and provision in a suitable form for use, it follows that work has to be done on the following subjects: Physics, Theoretical Physics, Chemistry, Metallurgy and Engineering. Besides these, a division for the control of health had to be set up.

For the staffing of the Establishment, we had the advantage of the nucleus which was sent out from England to the American project and to the Chalk River Establishment in Canada. This staff, experienced in the work, has had to form the backbone of the Establishment. We were also able to take over blocks of staff from other war-time government establishments. One of these, from the Telecommunications Research Establishment, Great Malvern, has formed our Electronics Division, and another from the Royal Aircraft Establishment, Farnborough, has made the nucleus of our Metallurgy Division. Owing to lack of accommodation at Harwell, the first of these two divisions is still working at its original establishment, though we hope to move it to Harwell in the course of the next year. Owing to the nature of the war-time training, especially for radar, we have been able to recruit a very good type of physics staff for Harwell from other Government Establishments. The Physics staff is therefore approaching full strength, while staff in the other subjects is building up as rapidly as it can.

Work on "Gleep" Begun as Part of Broad Research Project

It has been the aim of the Establishment from the start to interpret atomic energy in a broad sense, since it was considered that it would not be possible to build a healthy Establishment if it were confined to a few projects of what might be called nuclear engineering. It was felt that the health of the Establishment would depend on scope being given for fundamental research work. Some major projects undertaken from the beginning fall into this category.

The main objectives of the Establishment were, as has been said, to be the piles, first a pile of very low power for experimental work and control of pile materials and then a pile of higher power for experimental work and the manufacture of tracers. Basic work on these piles had begun before the initiation of the Harwell Establishment, at Chalk River, and in various firms in England. We were thus ready to put the projects in hand and so we were able to announce in August, 1947 that the first pile had started to operate.

This pile is known as the Graphite Low Energy Pile or "Gleep." The concrete shield and its accessories had taken about one year to build and about the beginning of July, stacking of the graphite began, and was completed, well ahead of schedule, in

about one month. The uranium was then introduced slowly. As the neutron multiplication factor increased with increasing uranium, so the approach of the pile towards criticality could be noted by the readings of a BF_3 chamber recording the flux density of neutrons in the pile.

On August 7, when the pile contained several tons of uranium, the counter recorded 17 neutrons per minute. By August 11, the figure was 55 neutrons per minute, by the morning of August 15, 2,400 and by the afternoon 6,600. At this point the chamber saturated, the pile being almost divergent. On loading a little more uranium, the pile became divergent and worked at about 1/10th watt, the power increasing exponentially but with a very long time constant. The control rods were then somewhat withdrawn and the time constant increased so that the power rose fairly rapidly to 100 watts at which point the shut off rods which had been set for this figure operated and shut down the pile.

Since the middle of August, a considerable amount of work has been done on the operating characteristics of the pile. Recently, the simple cooling mechanism has been put into action and the power has been taken up towards the rated figure of 100 KW, and beyond that for short bursts. This pile was built for experimental work in physics and on materials, and its flux is small for the manufacture of tracers. However, we will be able to produce about 5-10 curies of radiophosphorus per month, though the low flux will only allow a low specific activity, unless an (n,p) reaction on S^{32} is used, which would reduce the output considerably.

Pile of Higher Power Will Produce Radioisotopes

In the next pile to be installed at Harwell (which we hope will work during 1948), the power of operation will be greater (several thousand KW) because the cooling of the uranium will be accomplished by passing a high speed stream of air in the channels round the rods. The metal will be sheathed with aluminium to prevent oxidation and to contain the fission products. The emergent gas temperature will be too low for the efficient production of electric power, but it is hoped to make some use of the heat of the pile for warming buildings.

The pile will operate at a neutron flux of something like 100 times that of the Gleep. This will make possible full production of nearly all the radioactive tracers required for this country. A few useful isotopes will be limited in quantity and a few others only manufacturable by use of a cyclotron.

The pile will also provide a powerful source of fission products, distributed among the 35 elements from Zn to Gd. At 1,000 KW, about 1 gr. per day will be produced. A small quantity of plutonium for experimental work will also be produced.

The pile will also be important in the study of the irradiation of various materials in an intense atmosphere on neutrons. Many of the properties of materials under such circumstances — materials of pile construction for instance—are not yet known in this country.

Pile for Power Production Involves Certain Problems

These piles will probably be followed by others more directly concerned with power production. There are many problems yet to be solved. For instance, we must aim at a much more efficient use of uranium 235, the only naturally occurring fissile material, than is contemplated in our existing types of pile. A more fundamental problem is to find out whether we can in some way use uranium 238 and thorium as nuclear fuels. Of course, it is known, for example, that uranium 238 is converted by neutron capture into plutonium, which is certainly a fissile material. But the only known way of doing this is to "burn" uranium 235. However, by the partial replacement of uranium 235 in a pile by plutonium, we should be able indirectly to "burn" some part of the uranium 238. In view of the obvious stringency of supplies of uranium 235 (present in natural uranium as only 1 part in 140), it will be important to find out how effectively such a process can be carried out in practice.

Development of Instruments to Deal with Specialized Problems

I will now turn to the other aspects of work on the Establishment. The next group of projects to be considered are those associated with the piles—the measuring instruments for radioactive radiation. These are ionisation chambers and Geiger-Muller Counters. The ionisation chambers are used for pile control and for the general monitoring of radiation in the buildings. The counters are used for the investigation of weaker radioactive radiation. These instruments form an essential part of the equipment, and a great deal of work has been put into them. Much of it has been done in Chalk River.

In Harwell, we have set up a group working on counters and ion chambers; in Malvern we have a strong electronics group and we also have a small one in Harwell. The Malvern group has been responsible for the provision of scalers for use with the counters and amplifiers for use with the ion chambers. Many more specialized problems also arise. A number of types of health instruments have to be developed. For example, one of these is a hand monitor for making sure that workers who have handled radioactive products have no residual activity left on their hands. Besides this, a number of instruments are being developed which are of great assistance in radiochemical work where a large amount of routine counting is required.

Then also there is the radiochemical work associated with the extraction and properties of highly active materials. At present at Harwell, there are no facilities for such work, since we only have an ordinary chemical laboratory, but the necessary chemical laboratories are being built. The ordinary chemical laboratory will be followed very shortly by a "warm" laboratory for moderate activities and next year we will have a "hot" laboratory for highly active work.

I do not propose today to speak about the metallurgical work, important though it is, for lack of time.

Aim Is to Provide Active and Inactive Tracers

One of the main aims of the Establishment is the provision of tracer elements for medical research work and as I have said, the piles will supply this need. The counting equipment we are developing will enable the material to be used as efficiently as possible.

It so happened that during the war a development of mass spectrographs was undertaken in this country. These have become available to us and have led us to branch out into the field of non-radioactive tracers, which are simply enriched specimens of known stable isotopes, such as C^{13}. For many biochemical uses, these are preferable to the radioactive tracers, since they do not involve active doses, and also elaborately prepared organic compounds do not decay away. Further, one element which is important, nitrogen, has no suitable active isotope. The mass-spectrograph is the analyzer for work with inactive tracers.

It was therefore decided to put in hand at Harwell work towards the preparation of inactive tracers, the most important of which are D, C^{13}, N^{15}, O^{18}, and S^{32}. It was known that N^{15} was being produced in the U.S.A. by a method known as chemical exchange. This is a reaction between ammonia and a solution of ammonium nitrate which tends to concentrate the heavier isotope N^{15} in the solution.

Methods for Producing Inactive Tracers

The work is done by allowing the gas to interact with the solution, which wets a large area of so-called "packing" in a long vertical column. This process is used commercially in the U.S.A. and we hope that a plant will also be set up in England in the near future. With C^{13} and O^{18} similar processes can probably be used, but there are difficulties. At Harwell, we are working on a modified process in which gaseous CO is allowed to interact with liquid CO at roughly liquid air temperature. This process shows considerable promise.

These methods are specialized for particular isotopes, but at Harwell we have the ambition to have available methods by which the isotope of any element can be prepared in small quantities. The simplest general method is that of thermal diffusion in which a gas is placed in a long vertical column down which passes, a heated wire or rod. The molecules containing the lighter isotope tend to concentrate at the cool outer wall, while those of the heavier isotope concentrate near the hot surface. Thus a convection is set up in which the lighter isotope is concentrated at the top of the tube. Several such tubes placed in series will give the required concentration of 20 - 50.

Also, we are planning an electromagnetic separation plant which will have the advantage that in principle any isotope can be separated even if it is one of the many. This is essentially a large, high current mass spectrograph. A large enrichment can be obtained. Thus we hope to separate isotopes of interest to nuclear physics such as K^{40} and Ca^{48} and many others. The quantities readily available will range between fractions of a gram and grams.

Machines to be Used for Particle Acceleration

Finally, I must say some words about the plans for pure nuclear physics research. Some lines of work have already been started, but I do not propose to touch on these. I must say a few words, however, about the machines which are constructed or under construction for particle acceleration. These are:

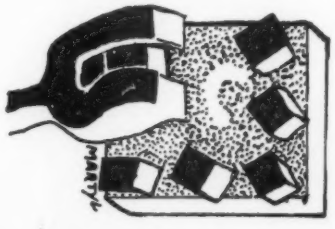
(1) Van de Graaff machine for protons or deuterons of 4 or 5 million electron volts.

(2) Synchro-cyclotron for protons of 150 MeV energy.

(3) Synchrotron for fast electrons.

(4) Linear Accelerator for fast electrons.

With regard to (1) the machine is already working and a voltage of about 3.75 MeV has been obtained with a pressure of 20 lbs. per sq. in. of freon and 80 lbs. of nitrogen. The problem now is to apply the voltage to the hydrogen ions so as to obtain a beam of fast protons or deuterons for experimental work. When this is done, we shall be able to work on nuclear reactions using protons or deuterons; also by means of the D-D reaction, we have a very convenient source of neutrons of defined energy for experimental work.



With regard to (2) although it is smaller than several machines being erected in the U.S.A., the Harwell cyclotron with 110" poles is the largest cyclotron at present under construction in England. We hope that it will be completed in the autumn of 1948. It is not designed for work on tracers since this will be carried out elsewhere. Its main features will be for experimental work on the properties of these high energy particles, for the study of nuclear reactions carried by the collision of these particles, and for the manufacture of many isotopic species, such as the transuranic elements from 93 upwards, for radiochemical research.

With regard to the synchrotron, we have no project to build a large machine for Harwell. We have, however, at Malvern, a very active group which was the first actually to demonstrate the feasibility of the synchrotron working, thereby producing electrons of 15 MeV from a small betatron designed originally for 4 MeV. A model of synchrotron for 30 MeV has been designed and will be working shortly; also our group is giving assistance to the synchrotron projects for 140 MeV and 300 MeV at Oxford and Glasgow.

Work on Linear Accelerator at Malvern

With regard to the linear accelerator, the Malvern group has had considerable success. They have had a trial length of accelerator working, which speeds electrons up from 50 KV to 500 KV energy, and another tube planned for 5 MeV will be going soon. Then the next objective will be the production of a machine for 20 MeV electrons of a length preferably not exceeding about 6 ft. The linear accelerator has the advantage that the main beam of particles can be got out into the air quite directly. Both the linear accelerator and the synchrotron may perhaps have important therapeutic applications.

I have tried to give a very broad picture of the many types of work being attempted at Harwell, and, in conclusion, I think we may claim that, bearing in mind the many practical difficulties of constructional and other work in post-war England, the Establishment has been successfully launched.

ATOMIC ENERGY IN THE NEWS

Statements by the U. S. Atomic Energy Commission

On February 3, the AEC announced a research fellowship program in the physical sciences basic to atomic research and development to complement that recently established in the biological sciences and medicine. An initial allocation of $1,500,000 has been made for grants to students in such fields as physics, chemistry, metallurgy, mathematics, geology, and astrophysics. The program will be administered by the National Research Council, and research will be carried out in university or other independent laboratories. The initial grants will consist of no more than 30 post-doctoral and 150 pre-doctoral fellowships. To avoid aggravating the shortage of college instructors, fellows will be allowed to do a moderate amount of teaching.

On February 27 the AEC announced the appointment of Dr. G. Failla of Columbia University as director of a health physics branch which will specialize in methods of protecting human beings from radiation and radioactive materials.

The AEC announced that only official U. S. observers would be present at the atomic weapons tests at Eniwetok and that no newspaper representatives would be permitted.

Publications on nuclear physics and radioisotopes have been made available by the AEC.

A volume entitled "Lecture Series in Nuclear Physics" is based on lectures given at Los Alamos in 1943 by scientists working on the development of the atomic bomb. The six sections of the book and the compilers are as follows:

1. Introduction and Terminology E. M. McMillan
2. Radioactivity—E. Segrè
3. Neutron Physics—J. H. Williams
4. Two-Body Problems—C. L. Critchfield
5. The Statistical Theory of Nuclear Reactions — V. F. Weisskopf
6. Diffusion Theory—R. F. Christy

Copies may be obtained from the Superintendent of Documents for 55 cents each.

A second document entitled "Background Material on Activity in First Year of Distribution of Pile-Produced Radioisotopes" may be purchased from the same source for 10 cents a copy.

New York City has established its own Committee on Atomic Information in response to appeals from the AEC that communities provide facilities for education in problems related to atomic energy.

Army Appoints Deputy Secretary for Atomic Affairs

The Army has announced the appointment of Donald F. Carpenter, vice president of Remington Arms Company, as deputy to Secretary of Defense Forrestal "in atomic energy matters." Mr. Carpenter also becomes the new chairman of the military liaison committee. Col. Kenneth D. Nichols, succeeds General Leslie R. Groves as head of the armed forces special weapons project and also as a member of the military liaison committee.

Major General Harold R. Bull, deputy chief of organization and training of the Army General Staff, urged the conference of Mayors to organize civilian disaster relief units in preparation for future atomic bomb attacks.

Report on Congo Uranium Mine

In the *New York Herald Tribune*, A. T. Steele reported a visit to the uranium mine at Shinkolobwe, in the Belgian Congo, stressing the atmosphere of secrecy surrounding operations there and the general interest in the hunt for radioactive materials in the surrounding territory. Statistics could not be obtained, but it was well known that most of the output of the mine goes to the U.S., and that our government is responsible for the insistence on secrecy.

FAS Council Meets

The Executive Council of the Federation of Atomic Scientists met in New York City on February 1, and discussed at some length plans for FAS reorganization and financial support and the possibility of holding an international conference of scientists to discuss social problems raised by new methods of warfare. Additional topics of discussion included security and clearance, atomic energy as an issue in the coming election, a National Science Foundation, the European Recovery Program, and whether or not the FAS should take a stand on Universal Military Training.

The Pope Addresses Academy of Sciences

In an address to the Pontifical Academy of Sciences on February 8, Pius XII called for a ban on the use of that "most terrible weapon," the atomic bomb, while praising the work of scientists that had opened the way for peaceful use of a rich resource of energy.

Scientists, the Pope said, "have ascended the Alps of knowledge, the mountains of speculative sciences, of calculus, of astronomy, the summits of the stars and the nebulae and you have descended into the plains of practical sciences with thousands of forms of arts, of technology, of experiment."

Quoting St. Augustine on the horrors of war and pointing out how much more horrible war has become by use of advanced techniques, the Pope continued:

"But abandoning for a moment the use of atomic energy for war and in the trusting hope that it will be used solely for the work of peace, one must regard it as an investigation and application truly of genius of those laws of nature which regulate the intimate essence and activity of inorganic matter . . . .

"All the work of scientists will not rest until they have discovered an easy and secure manner of governing the process of the fission of the atomic nucleus in such a manner as to place in the progress of civilization its rich resources of energy.

"The admirable conquest of the human intellect which taxes and investigates the laws of nature is carrying humanity with it along new roads."

LOYALTY CLEARANCE PROCEDURES IN RESEARCH LABORATORIES

Committee on Secrecy and Clearance,
Federation of American Scientists

The following study of clearance procedures is a preliminary report signed by the following members: S. H. Bauer, chairman, H. A. Bethe, L. M. Brown, P. J. W. Debye, G. K. Fraenkel, A. R. Moore, P. Morrison, R. S. Rochlin, R. R. Wilson. The committee is now engaged in preparing more detailed analyses of the material that has been collected. This article appears simultaneously in the April 2 issue of SCIENCE.

The possible military applications of scientific research have raised several serious problems for scientists in the past few years. Of these, the problem of clearance procedures and loyalty determination has proven one of the most vexing. It has involved not only scientists working in government laboratories, but also those in university, industrial, and other private laboratories.

In the belief that sufficient information on present clearance procedures has not been readily available to most scientists, this Committee was formed to survey and report on the current situation in various types of research laboratories.

Sources of Information Used by the Committee

In November, 1947, a questionnaire was sent to the directors of 140 research laboratories throughout the United States. The Committee went over lists of research laboratories operated by universities, industries, and the Federal Government, and selected at random a representative number from each group. The larger laboratories in the fields of physics, chemistry and biological sciences were favored in our selection. A letter was enclosed which described the purpose of the survey and stated that the results would be published.

Replies were received from 57 laboratories, as listed in the table below.

Although a number of the replies were incomplete or evasive, the questionnaire yielded considerable useful information.

The Committee has collected many documents, articles, and newspaper clippings pertaining to clearance procedures. A number of selected references are listed at the end of this report; numbers in brackets refer to this list.

In addition, members of the Committee have corresponded or had conversations with government and laboratory officials, with about 15 scientists who have been denied clearance, and with other informed persons. We wish to thank all those whose cooperation has enabled us to collect and present this information.

Type of Laboratory	Questionnaires Sent	Replies Received	Percentage Replying
Atomic Energy Commission	9	3	33%
Armed Forces	25	4	16%
Other Government Laboratories	19	10	53%
Industrial and Private	39	14	36%
Universities	48	26	54%
TOTAL	140	57	41%

This article does not attempt a complete presentation of all the data collected, but will merely summarize the salient points. The Committee hopes to publish additional detailed information in further articles. The results of the survey will be reported under the five headings named in the above table.

Provisions of the Atomic Energy Act

According to the Atomic Energy Act of 1946 [9], no individual may be employed by the Atomic Energy Commission or have access to restricted data "until the Federal Bureau of Investigation shall have made an investigation and report to the Commission on the character, associations, and loyalty of such individual". After receiving this report, the Commission itself has the responsibility of evaluating and interpreting the report and of deciding whether to grant or withhold clearance. It should be noted especially that the law indicates that the Commission should consider "associations" as well as "loyalty" in making this decision.

Since the Commission must rely almost entirely on the F.B.I. to obtain facts about a given individual, there are likely to be cases where it is difficult to make a decision. These may arise from false information given to the F.B.I. by persons who dislike the scientists concerned, from possible cases of mistaken identity, from mistaken interpretation of actions which appear questionable, or merely because the available facts put the case in the "borderline" region. It then becomes important to know what procedures the Commission has set up to safeguard loyal scientists against unnecessary clearance denial, with its

attendant stigma and possible restrictions on ability to obtain another position. [1, 2, 3, 4]

Procedures Followed by the Atomic Energy Commission

Since it took office in January, 1946, the Commission has been attempting to devise procedures which would safeguard restricted data to the maximum extent and at the same time protect its employees from unfounded accusations. This task has not been simple. The interim procedures followed by the Commission have usually included some type of interview with the individual when requested. However, such issues as providing a specific detailed statement of charges and permitting cross-questioning of witnesses have yet to be resolved. In many cases the Commission and F.B.I. feel unable to permit these for "security reasons". The accused, on the other hand, have claimed that they cannot prepare an adequate defense against unnamed charges nor against investigations which cannot be independently checked.

Furthermore, there have been made public no criteria for judging such cases beyond the words "character, associations, and loyalty". Meanwhile a number of cases arising in various laboratories operated by the Commission have aroused widespread discussion, both at those laboratories and elsewhere. We have learned that many loyal scientists, lacking either knowledge of the criteria for clearance or confidence in the fairness of their application, have considered leaving the employ of the Commission for positions where they would be secure against unfounded accusations. Others, not now employed by the AEC, hesitate to apply for such positions for similar reasons. To the extent that this has occurred or may occur, the nation's atomic energy research will be impaired.

These problems are especially acute in those AEC laboratories where unclassified (non-secret) research is carried on. Our survey indicates that some type of clearance is required in these laboratories even of scientists who have no access to restricted data.

The above discussion applies, of course, to employees of contractors and licensees of the Commission as well as to employees of the AEC itself.

In addition to injury to innocent individuals, there is another factor which has concerned various groups of scientists. They feel that the atmosphere of fear and uncertainty engendered by occasional unfounded clearance charges may cause many scientists to withdraw entirely from any type of civic responsibility. In the field of social implications of atomic energy, in particular, it is of extreme importance that scientists continue their efforts to inform the public of all facts needed for sound policy decisions.

The tremendous expansion which atomic energy research is likely to undergo in the years to come, and the exclusive control held by the Commission over many aspects of nuclear research, both testify to the great importance of establishing proper precedents in this area.

In order to help resolve these problems, the Atomic Energy Commission appointed in January, 1948, a "Personnel Security Review Board," headed by Owen J. Roberts, former associate justice of the U.S. Supreme Court. The other board members are Karl T. Compton, president of the Massachusetts Institute of Technology, Joseph C. Grew, former Undersecretary of State, George M. Humphrey, president of the M. A. Hanna Co. of Cleveland, and H. W. Prentis, Jr., president of the Armstrong Cork Co. of Lancaster, Pa., and former president of the National Association of Manufacturers. At this writing the Board has not yet made public any statement of policy.

Procedures Followed in Military Laboratories

Under Public Law 808, [9] approved December 17, 1942, any civil service employee of the Army, Navy or Coast Guard may be summarily removed if the Secretary concerned considers such immediate removal "warranted by the demands of national security". Persons so dismissed are entitled to "be fully informed of the reasons for such removal" and may submit statements or affidavits in their own defense. They are not entitled to confront witnesses, nor to appeal a case outside the Department concerned. [5]

According to the New York Times of Nov. 21, 1947, over 75 civilian employees of the Army and Navy have been dismissed since 1942 on charges involving disloyalty. A much larger number, "under suspicion of disloyalty" were earmarked for release "for reasons of payroll cutbacks".

Scientists who have been denied Army, Navy or Air Force clearance have made the following assertions to this Committee:

1. They have sometimes been unable to obtain either a statement of charges or a hearing.

2. When charges were stated, they sometimes consisted only of membership in liberal, non-Communist groups, or similar reasons, indicating that the statement was either incomplete or insufficient. The accused were sometimes not even permitted to make a written copy of the charges.

3. Prospective employers were told that such discharge was for loyalty reasons, although these employers had no connection with military or secret work.

4. Laboratory officials have urged scientists to resign without statement of charges or a hearing, on the grounds that an appeal will be fruitless and that if unsuccessful, will look bad on the man's record. The scientists consider this tantamount to pressing them to admit guilt concerning charges of which they are ignorant.

5. Many of those refused clearance had been cleared for highly secret work during the war, and do not know why they should suddenly be accused of disloyalty.

6. Sometimes a new employee is not refused clearance, but is not permitted to start work "pending complete investigation". This indeterminate condition may last for over a year, by which time the scientist is likely to have given up and found a position elsewhere. This mechanism permits the military authorities to avoid statements of charges or hearings.

In view of the serious nature of these charges made by dismissed scientists, we were especially interested in learning from the directors of military laboratories what their official procedures are. Of all types of laboratories we surveyed, however, the military laboratories were least cooperative in replying to our questionnaire. In fact, only a few of the smaller laboratories sent in replies which were not completely evasive. It may be assumed that military officials have little interest in safeguarding their employees or em-

ployees of their contractors against unfounded charges. This may help to explain why these laboratories are having increasing difficulty in obtaining and holding scientific personnel.

Other Government Laboratories

President Truman's Executive Order 9835 of March 21, 1947, [6] the so-called "loyalty order", applies to all 2,000,000 employees of the executive branch of the Federal Government, and hence includes the many scientists who staff research laboratories financed by the Department of Agriculture, the National Bureau of Standards, the Smithsonian Institution, Bureau of Mines, the Food and Drug Administration, etc. In general the work of these laboratories is not secret.

It may be of interest at this point to summarize the major features of this loyalty order.

All present employees are to be investigated. Any employee charged with being disloyal is entitled to an "administrative hearing" before an agency loyalty board, and has the right to appeal to the 20 member Loyalty Review Board, headed by Seth W. Richardson. [8] However, the finding of either board is to be merely advisory; the department or agency head may dismiss an employee even if he is acquitted by such a board.

The charges shall be stated to the employee "as specifically and completely as . . . security considerations permit". The F.B.I. or Civil Service Commission "may refuse to disclose the names of confidential informants" even to the Loyalty Review Board. The defendant, therefore, may have considerable difficulty in proving his innocence. [10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

The standard set up for refusal of employment or removal from employment is that "on all the evidence, reasonable grounds exist for belief that the person involved is disloyal to the Government of the United States . . . . Activities and associations of an applicant or employee which may be considered in connection with the determination of disloyalty may include one or more of the following: . . ."

After listing such standard items as treason, espionage, and sedition, the list concludes with "membership in, affiliation with or sympathetic association with" any organization designated as subversive by the Attorney General. In regard to such designation the order does not require that this list of organizations be made public. The present Attorney General did, however, publish on December 4, a list of about 90 groups. [7] There is no provision for such organizations to appeal the decisions of the Attorney General.

In the case of all applicants for employment, an extensive investigation of loyalty is also required, but here the order fails to provide for any statement of charges or appeal.

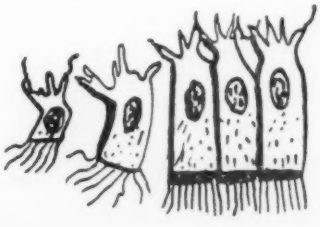
Over ten million dollars has been appropriated to carry on the extensive investigations required by this order.

Industrial Research Laboratories

Of the 14 leading industrial and private laboratories which answered this Committee's questionnaire, nine do part of their research work under contract with the Army, Navy or the AEC. Of these nine, eight of the contracts involve work classified as secret. The personnel involved in this work are of course subject to the same clearance procedures as outlined above for the AEC and military laboratories.

An issue which has caused considerable discussion in the case of such contracts involves clearance of scientific personnel engaged solely in non-secret research, not connected with government contracts. Certain laboratory administrators advocate requiring clearance for all their employees as a condition of employment, to permit free discussion of secret work between those actively engaged in it and their colleagues who are not. Groups of scientists have objected to this procedure, maintaining that:

1. Under present clearance procedures, a man may be denied clearance by error or because he is considered a poor "security risk" through no fault of his own.



2. If many laboratories adopt such a policy, the scientist's entire field of specialization may be practically closed to him, despite his willingness to do no work connected with military or secret matters.

3. It has been charged that some laboratories have used this approach to eliminate unwanted personnel.

At present this issue has not been wholly resolved. Among three leading research laboratories in the electrical industry, for example, one requires clearance for all scientific personnel, although less than half its work is secret. Another has decided to isolate its secret work and not subject its other employees to any clearance procedure. The third requires clearance of all new employees and attempts to get it for all old employees; among old employees denied clearance, some have been dismissed and some have not. The policy in that laboratory seems to be still in the formative stage.

University Research Laboratories

Replies to this Committee's questionnaire were received from 26 university laboratories, representing the fields of physics, chemistry and biological sciences in the country's larger universities. Of these, 23 or 88% do part of their research under contract with the Federal government, mostly Army and Navy, and 11 derive over half their research funds in this manner.

Six of these laboratories (23%) indicated that part of their research involved work classified as secret and consequently required personnel security clearance by the appropriate government agency.

In this connection it may be of interest to quote from the report issued on August 27, 1947, by the President's Scientific Research Board, headed by John R. Steelman. The report recommends: "As a matter of policy, no secret or confidential research or development projects should be placed with universities in time of peace. Every effort should be made to transfer these projects to Federal establishments."

Because the traditional freedoms of thought, expression, and research have long been cherished in universities, it is of special interest to investigate the extent to which "loyalty" and "security" problems are affecting our campuses. One question

asked by this Committee concerned the attitude of the laboratory director or department chairman toward employing scientists to do non-secret research for which they were well qualified, but who had been previously denied security clearance elsewhere. "The previous clearance refusal would not affect the likelihood of our employing him," was the answer for 16 laboratories. Four directors indicated that they would be very hesitant to hire such a person. In the case of two of these, the universities had contracts for secret work; in the other two cases, no secret work was being done in the laboratories.

Conclusions Reached By the Committee

Our investigations have shown that large numbers of scientists have become concerned over allegedly arbitrary dismissals of certain of their colleagues. Scientists who used to consider that their positions depended only on the value of their scientific work, now find that their political beliefs are also being investigated, even when their research has no connection with the government. Upon examining the laws and regulations under which clearance procedures are administered, they find few safeguards against mistakes or arbitrary abuses.

The files of this committee contain many letters from biologists, chemists, engineers, and physicists unable to learn why they are subjected to the financial loss and personal embarrassment of clearance denial. The letters often contain lengthy passages on their belief in democracy and their frustration at being unable to speak in their own behalf

It has been repeatedly emphasized by government officials that when doubt exists as to the loyalty or even the probable future behavior of an employee, the doubt is resolved in favor of the Government. Hence, it is argued, no stigma should be attached to a person denied clearance, since it may not have been his fault at all. The dissemination of such an attitude has indeed much to recommend it.

As a practical matter, however, it seems evident that most persons do hold such a record against a man, and that his personal reputation and often his ability to obtain another position are seriously jeopardized. Therefore, every effort should be made to make clearance procedures as fair and just as possible in those fields where they are necessary, and to restrict these procedures to those fields. The accomplishment of this aim will require continuing careful study and wholehearted cooperation on the part of both public officials and scientists.

FAS Resolution on Clearance

It is pertinent to quote the following resolution on clearance procedures, which was passed on December 28, 1947, by the Council of the Federation of American Scientists:

"There should be separate policies for classified (secret) and unclassified research, as follows:

"Policy A, for unclassified work.

"There should be no type of "loyalty check" either for employees or applicants for employment. If an applicant had previously been refused security clearance for classified work, this should have no effect on whether or not he is employed.

"This policy should be held by all laboratories doing no classified work, including university, industrial, and government laboratories. Laboratories engaged partly in secret work should apply this policy to their entire unclassified program, and isolate their secret work from employees who are not cleared.

"Policy B, for classified work.

"1. Although general criteria for clearance are difficult to set down precisely, we object to unreasonable criteria, such as "guilt by association" or use of rumors not substantiated by full investigation.

"2. Procedures should ensure that if an employee or applicant for employment is refused clearance, this fact cannot be learned by the public or by future employers unless (1) such employer does classified work which requires clearance, or (2) the employee himself chooses to reveal the clearance refusal.

"3. In all challenged cases of clearance refusal there should be a hearing before a jury selected from a panel of working scientists within the area of secrecy. The employee should receive a detailed statement of the charges against him. There should be an effective means for an independent check on evidence presented at the hearing, including the right of the accused to cross-question witnesses, and adequate provision for appeal."

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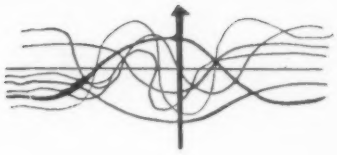
NUCLEAR FISSION AS A SOURCE OF POWER



John R. Menke

The following article presents preliminary estimates of the economic importance of nuclear energy and is part of a study being conducted by the Cowles Commission* at the University of Chicago under the direction of Dr. J. Marschak, and Dr. Sam Schurr. Mr. Menke joined the Manhattan Project as an engineer in 1942, and is now on the staff of the Clinton Laboratories in Oak Ridge. This article has appeared in ECONOMETRIKA and is reprinted by permission of its editors. Minor revisions have been made by the author.

Introduction

The announcement of the atomic age on August 6, 1945 at Hiroshima brought to a close its scant fifty-year period of gestation. Civilization is thus presented by the new era with significant new problems; we may classify these problems in three groups as the enlightened use of: atomic bombs and energy by the military, nuclear research tools by science, and fission energy as power by industry.

The first class, enormously important in its negative, dangerous aspects implies political problems portending "one world or none." May that portent be a good one. The second class holds forth all the promise of new insight into medicine, biology, chemistry, and physics. In these fields a new "one world" could achieve prosperity. This paper will deal with the third, possibly least important class, the effect of atomic energy on the cost of power. Such discussion is a necessary preliminary step to any analysis of the total economic effect of atomic energy and of the policies that might maximize its benefits to society. The economic problems of nuclear energy and the need for adequate policy have in fact been recognized in the atomic-energy bill passed by the Congress.[1]

The examination of the effect of nuclear fission, a source of atomic energy, on the cost of industrial power will constitute the problem of this paper. At present the only feasible agency for making use of atomic energy is the pile. It will be valuable here to give a brief, functional description of such a pile within the limits of security.

Description of a Pile

2.1. In general usage the term "pile" means a lattice of fissile material, such as uranium 235, with moderator, shield, controls, and other necessary appurtenances arranged to give a controlled fission chain reaction. It is not considered within the scope of this report to give more than an economic viewpoint.[2]

In one functional respect a pile is similar to a hydro-electric plant with its many products such as energy, water for irrigation, flood control, navigation, fish propagation, etc. It is even more similar in an economic sense to a chemical plant with its many products which can be sold or fed back into the production processes.

A pile may be considered as a source of three things: Energy as heat, and other local radiations, new fissile material such as plutonium, and other radioactive elements. Dependent upon the design, a pile can be built to emphasize the production in useful form and amount of any or all of these products.

2.2. We will consider the composition of the input (cost) first, and, later, each of the products separately, both qualitatively and quantitatively.

Input: A. Materials:
- a. A certain amount of fissile material, say uranium 235.
- b. About an equal amount of a cheap and relatively plentiful fertile material such as uranium 238, the more abundant isotope in natural uranium, as more fully discussed below.
- c. Other materials such as moderators, coolants, and chemicals for purification.

B. Labor:
- a. For operation of pile and heat engine.
- b. For maintenance.

C. Fixed Costs:
- a. Interest on investment.
- b. Depreciation and insurance of plant.
- c. Overhead for supervisory personnel.
- d. Taxes.

While all the input costs may be important, we shall keep in mind the unit of input of one pound of, say, uranium 235 for the discussion of products which follows.

2.3. A. At present the pile can be considered as a source of commercial energy only in the form of heat. It is this heat energy that is thrown away at Hanford in such enormous quantities because it is available only at a small temperature difference relative to the cooling water. Never-

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*Cowles Commission Special Paper, No. 1. Numbered references in square brackets refer to items in Bibliography at the end of this paper.

The author wishes to state that the paper was substantially completed in June, 1946, and declassified in June, 1947. This accounts for the absence of reference to the report prepared under Dr. Charles A. Thomas and published in the latter half of 1946 on behalf of the United States representative to the United Nations Atomic Energy Commission. Data from this report have been used in the analysis by Sam H. Schurr (*American Economic Review*, Vol. 37, May, 1947, to be circulated as Cowles Commission Special Paper No. 2. (See also Phillip Sporn's discussion, and Schurr's reply, *ibid.*, pp. 110-117.)

1. The Atomic Energy Act of 1946 [1] states that "Research and experimentation in the field of nuclear chain reaction have attained the stage at which the release of atomic energy on a large scale is practical . . . It is reasonable to anticipate, however, that this new source of energy will cause profound changes in our way of life."

The bill provides specifically for: "A report to the President . . . stating the Commission's estimate of the social, political, economic and international effects of such use . . . and recommendations for . . . supplemental legislation."

2. Sources giving descriptions of piles from different viewpoints are references [2, 3, 4, 5, 6, 7, and 7a].

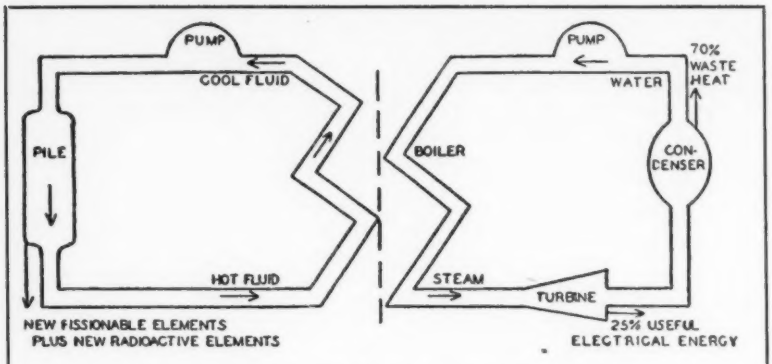


FIGURE 1.—Pile-steam electric power plant, schematic.

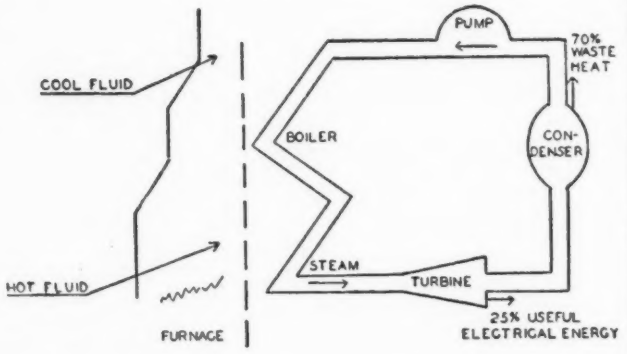


FIGURE 2.—Coal-steam electric power plant, schematic.

theless, this heat will undoubtedly become available in a useful form in the future, that is, with a usefully large temperature difference.[3] In the generation of heat the pile is analogous to a furnace used to burn coal and heat water in a steam-boiler power plant, or to a furnace used to supply process heat in any industry.

Local radiations, a form of energy, such as X-rays, might conceivably be used on the spot for industrial or medical purposes. But it is not likely that they will assume economic importance in the near future.

B. A new fissile element such as plutonium is more difficult to recognize as an economic good. The difficulty lies in the fact that it has two uses: Military, for bombs; and economic, as fuel for piles. Strictly speaking, it has two values, the first of which is very difficut to measure. By assuming extreme values for the military demand we can avoid this difficulty.

C. The other radioactive elements, the fission fragments, have utility in research and probably in other limited-demand fields. If, for instance, the problem of the photosynthesis of organics can be solved with radioactive tracers as tools of research, then the available amount of food and energy can be increased enormously. While these radio-elements have enormous usefulness as research tools, it is not likely that they will quickly become products of economic importance in themselves.

2.4. The above qualitative description of the pile product can be pictured as coming from a plant such as that shown schematically in Figure 1. Figure 2 is added directly under Figure 1 to show the degree of similarity of a pile power plant and an ordinary coal-burning power plant.

3. Reference [4]; especially paragraph 4.10, 6.32, 6.41, 8.54; and Reference [7].
4. There are references in the literature which estimate 11.4 million kilowatt-hours per pound [2 and 6], probably too high.

It will be seen that the diagrams are identical on the right-hand sides. There is no important difference between the systems that make use of heat from the pile and heat from the coal furnace. This similarity enables us later to estimate the cost of operation and maintenance of that part of the pile system from published data on steam power plants.

The quantitative question now arises: how much product for a unit input, one pound of fissile material?

2.5. Products: A. *Energy.* The amount of energy released in a typical fission process is well discussed in the literature. Smyth in his official report said that roughly 200 million electron volts of energy are released in every fission. This is equal to about 10 million kilowatt-hours of heat per pound of uranium 235 or plutonium fissioned.[4]

2.6. B. *New Fissionable Elements.* The amount of new fissile elements formed per pound of uranium burnt (fissioned) is now held secret. However, references are made in the literature that permit a useful approximation to be made. These results are summarized in Table 1. The diagram, Figure 3, from Smyth [4] illustrates the fission process well.

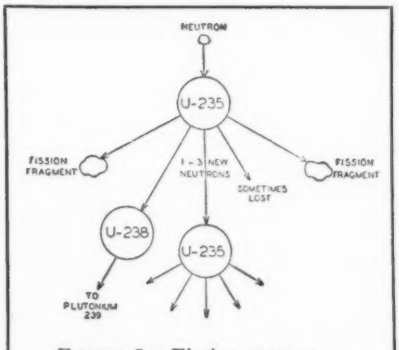


FIGURE 3.—Fission process.

TABLE 1

NEUTRONS PER FISSION

Source	Date	Estimate
[10]	1939	about 2.3
[11]	1939	about 3.5
[4]	1945	between 1. and 3.
[5]	1946	about 2.

Let us choose the latest published estimate, two neutrons per fission, for our purposes. It is, also, reasonably close to the average published estimate. These neutrons are either:

a. wasted, b. used in the "chain" reaction to cause the next fission, or c. used to make plutonium. If the number of effective neutrons, N, is as small as one, then the chain reaction will just continue producing energy, but without producing any new fissile element, until it has "burnt" up too much fissile material to maintain its "critical" size. Since it is known that the pile at Hanford did produce plutonium, it is apparent that N, the effective number of neutrons per fission, can be made greater than one.

If N is equal to two, then the chain reaction will continue and will in addition produce as much new fissile material as it burns old.

If N is more than two, then the chain reaction will continue, will replenish what it burns, and will in addition create some new fissile material left over to "sell." One can, of course, also "sell" the new fissile material that might have been used to replenish the pile. The pile would then eventually burn itself out again, slowly or quickly, depending only upon the amount of fissile material built into it and upon the rate at which this is burnt.[5]

5. In this regard the safeguarding of resources must also be considered. The optimum use of available supplies of uranium and thorium requires long-range planning. Dr. Szilard [8] before the Senate Committee on Atomic Energy testified: "With your permission, I will assume that the quantity of fissionable substances which can be produced might be expected to increase from year to year in geometrical progression . . . the time in which the production would double might be less than 1 year and might be more than three years . . . the years from 1946 to 1949 or from 1946 to 1958 ought to be considered as 'the building-up period.' During such a period it might not be advisable to divert any substantial quantities of the fissionable substances for the purpose of being 'burned' in order to produce electrical power. After such a 'building-up period,' however, there is no reason why we should not 'burn' up some 20 tons of fissionable material per year and produce electrical power at the rate of about 15,000,000 kilowatts." Also see J. A. Wheeler [3] for description of these regenerative processes: "The other possible outcome is more favorable to economy of raw materials. In every day of operation in which we destroy 1 kg. of fissionable material we synthesize from an inert substance more than 1 kg. of new fissionable material say, for example, 1.1 kg. In this case we leave 1 kg. of the new product in the plant to make up for the losses of the day and remove the other 0.1 kg. to help start up a new pile; or, if necessary to help make atomic bombs. In case we can achieve this outcome, there is no need for us to supply new fissionable material to our plant from the outside except to get it started. After it is in operation we could even feed it as raw material uranium from which all of the active constituent, U235, has been extracted, although it would be cheaper to use natural uranium. The plant itself will convert the inactive uranium to fissionable material for use in the chain reaction. Evidently we have only to design a plant with sufficiently good regeneration characteristics in order to use for power purposes all the uranium, not merely the rare constituent U235."

Two effective neutrons per fission as assumed here will, therefore, yield about one pound of *new* fissile element for each pound of uranium 235 burnt.

2.7 Products: C. *New Radioactive Elements.* For each pound of uranium 235 that undergoes fission we will get almost one pound of new radioactive elements. The fission fragments are the new radioactive elements and weigh within a few per cent of the original unbroken nucleus.

A list of the more abundant fission fragments suggested by the Smyth Report [4] as found in the normal fission chain reaction is given in Table 2.

TABLE 2

FISSION PRODUCTS

Mass Numbers 83-115		Mass Numbers 127-154
Yttrium	more abundant fragments	Cesium
Zirconium		Barium
Columbium		Lanthanum
Molybdenum		Cerium
*Masurium		Praseodymium
Ruthenium		Neodymium

*Name not definitely assigned

Other elements [3], [9] can be activated by subjecting them to the tremendous neutron bombardment available in the pile. However, these elements use up neutrons that would otherwise cause fission (produce power) or make plutonium. They are thus not the normal consequence of the chain reaction.

2.8. To recapitulate, then, for each pound of *fissioned* (burnt) *uranium 235* together with one pound of ordinary uranium we get:

a. about *10 million kilowatt-hours* of energy in the form of heat,
b. about *one pound of new fissile element* (e.g., plutonium),
c. about *one pound of new radio-elements.*

More complete descriptions of piles and pile operation, but from different points of view, are given in the literature from which this description is taken.

Resources

3.1. Only if the total amount of nuclear energy available in metals at mineable concentrations is significantly large is it worth while to consider the cost.

Uranium and thorium are the most likely primary, natural sources of nuclear energy for the reasonably foreseeable future. Both elements are metals of moderate abundance in the earth's crust. Roughly, the two metals, taken together, are as abundant, let us say, as lead. However, they do not occur in well-segregated ore bodies like lead, silver and gold. They are of an ubiquitous nature, being found in many igneous, and sedimentary rocks, almost always in very low concentration [12, 13, 14, 15, 16, 17].

3.2. Information available before 1941 [23, 24, 25, 26, 27, 28] indicates that the then known "commercial deposits" of uranium contained about 10^8 *pounds* of metal. These deposits are mainly situated: in the Belgian Congo, at the copper mines in Haut Katanga; in Canada, at the Great Bear Lake; and in the United States, in Colorado and Utah. "Commercial deposits" might be defined as greater than one-percent concentration in the ores mined before 1941. Goldschmidt [19] suggests that about 4 parts per million of the earth's crust is uranium. If we estimate that one-third of the earth's area, 6×10^7 square miles, is available, then 4 parts per million represents a total of about 10^{16} *pounds* of uranium in a 3-mile deep layer. (The earth's crust weighs about 3×10^{13} pounds per cubic mile.) The deepest mines are now about one mile deep; the deepest holes, oil wells, are about three miles deep.

There is, therefore, available to the world somewhere between 10^8 and 10^{16} pounds of uranium. The demand for energy in the world and in the United States in 1940 has been estimated [19, 20, 21, 22].

World fuel consumption in all forms recently is equivalent to about 2×10^6 pounds of uranium per year. The full utilization of uranium 235 and uranium 238 which goes to make plutonium is assumed here [29, 30, 31, 32].

It will be seen then that even the minimum figure of 10^8 pounds of uranium is a significant reserve of energy, more than is available in proven petroleum reserves (equiv-

TABLE 3

WORLD RESOURCES
(In terms of uranium)

	Available
Minimum Uranium	about 10^8 pounds
Petroleum	less than 10^7 pounds
Coal	more than 10^{11} pounds

TABLE 4

RESERVES AND COSTS

Concentration	Pounds of metal in U. S.	Cost per pound of metal
1.0% and higher	10^7	
0.1%	10^8	$ 5.
0.01%	10^9	$ 50.
0.001%	10^{10}	$500.

alent to less than 10^7 pounds of uranium) but much less than is available in coal reserves (equivalent to more than 10^{11} pounds of uranium); see Table 3.

The minimum amount of uranium available alone constitutes a significantly large reserve of power and consequently warrants further economic study as a source of power.[6]

3.3. Thorium is probably a source of power of similar magnitude to uranium. While many of the published studies of thorium date back to 1910-1915 when it was widely used as thoria in Welsbach incandescent gas mantles, a general estimate can be made from these old and incomplete data. Sands that contain the mineral monazite are found in three important localities: in the province of Travancore on the southwest tip of the Indian Peninsula, in Brazil, and in the United States, in North Carolina, and Virginia [33, 34, 35, 36, 37, 38, 39].

Indications are that the larger sand deposits in Brazil and Travancore contain in 0.5-1.0% concentration between 10^7 and 10^8 *pounds* of thorium. Estimates by geochemists of the concentration of thorium in the earth's crust, about 11.5 parts per million, taken for the same part as was considered before, yield a total of 10^{16}—10^{17} *pounds* as an upper limit for the total thorium available. Thorium then, is also a significantly large reserve of power.

Goldschmidt [20] suggests that both uranium and thorium belong to a "silicon" group of rock-forming minerals, that is minerals that do not separate out of a silica-high solution. This theory is consistent with the large over-all abundance of the two minerals and with the general rarity of rich segregated ore bodies. However, one might argue instead that the search for the two minerals is new and incomplete.

Availability and Cost of These Materials

3.4. To conclude the consideration of our first factor in the cost of nuclear power, the relative importance of the total amount available, we will look more closely into the availability of the totals delineated in Sections 3.2 and 3.3. Ideally, we should know the function that gives the amount of material available to the world at each concentration of metal in the ore. Dr. Clark Goodman [20a] of the Massachusetts Institute of Technology was able to approximate this function for the United States. In the rough terms in which such estimates must be made, Table 4 gives some of his results together with cost estimates made by the author.

The cost estimate has been obtained as follows: The product of the 1937 price of many metals with the concentration of metal in marginal mines gives an average figure of about 0.5 cent per pound of ore. Since the work involved in each case was common to any type of underground mining it is not surprising that nearly a constant figure resulted. Clearly no answer is given here to the question as to the range of concentrations at which the economic limit of mining will be found. That is a proper subject for a detailed future study. At least it is clear that the amount available is indeed significant.

Effect of Atomic Energy On The Cost Of Power

4.1. The effect of atomic energy on the cost of power can be examined by considering the following factors: The present cost of power and its variation with coal price, and the anticipated cost of nuclear power.

Let us now examine the first problem, the present cost of power.

In comparing the cost of producing electrical power by nuclear fission and the cost of coal-burning, steam-electric plants, a word of warning is needed. No implication is meant here that uranium will *substitute* for coal. Coal will retain its value as a chemical, e.g., in the reduction of ores and in the synthesis of organics. Furthermore, coal will retain a strong position as a fuel, both because of the enormous coal reserves and because of an awakening technology.

The similarity shown in Section 2.4 permits a more direct comparison than do the other forms of utilizing energy. It will be convenient to consider the cost to the generating plant of the electric power produced *"at the bus-bar"* [40, 41, 42, 43, 44, 45]. This means that costs of the generating station, both fixed and direct, will be considered. However, the costs of transmission, distribution, and customer relations (meter reading and bill collecting) will not be considered. These latter categories represent about 2/3 of the domestic consumer's bill.

4.2. What then, is the cost of electrical power at the bus-bar? Data compiled from the sources given above indicate that coal-steam electric power costs from 0.4 to 1.5 cents per kilowatt-hour in representative plants in the United States and, in comparison, that hydro-electric power costs from 0.05 to 0.4 cent per kilowatt-hour. Sales *revenue* for both forms in the United States for 1940-44 averaged between 1.7 and 1.5 cents per kilowatt-hour. The difference is represented mostly by the distribution costs. Large consumers pay very lit-

6. Estimates of mineral reserves must be accepted in the proper light. Uranium and thorium are only recently (within less than, say, forty years) in great demand and figures quoted above are only from information available before 1941.

The testimony of R. E. Wilson of the Standard Oil Company (Indiana) before the Special Committee Investigating Petroleum Resources, U. S. Senate, October 3, 1945 can be repeated here with value in the discussion of mineral reserves:

"The unfortunate experiences of our sober and highly regarded U. S. Geological Survey makes any group reluctant to undertake projections except with many reservations—in 1918 the Survey estimated the total crude (oil) reserves underlying the country to be around 6,500,000,000 barrels and most contemporary geologists were included to concur. Actually we have since that time produced 25 billion barrels and have today proven producible reserves of more than 20 billion barrels, a total already seven times that estimated by the survey."

In 1918 oil had been an article of commerce for fifty years.

tle more than the bus-bar costs for power.

4.3. Since we have chosen to use coal-steam electric power in comparison with atomic power, let us examine a breakdown of such a plant's costs. Table 5 below represents values for a very efficient (thermal) plant running at a higher-than-average load factor. The national average for thermal efficiency was 0.21 in 1940 and 0.44 for load factor in the same year. These values were chosen in order to compare the better present practice with a new development.

Thus, fuel represents 40 per cent of the total bus-bar cost with 0.5 load factor. If the same plant were run at a load factor near unity, the total cost would be about 0.6 cent per kilowatt-hour and fuel would represent about 50 per cent of the total.

Fuel costs may, of course, be very much higher in localities remote from sources, coal being as high as $12 per ton at some seaports. The effect of different coal prices on power costs is indicated in Table 6.

4.4. Remembering the similarity of piles and coal-steam plants, Section 2.4, we can now make a first approximation of a *lower limit* to the cost of pile power, the second question in our consideration. Let us assume that the pile replenishes itself (Section 2.6), and let us also neglect the purification costs, so that our fuel cost is zero. Then, if we further assume that the capital and other operating costs are similar to those of the coal-steam plants, we can see that the total power cost will be reduced by, say, 0.3 cent to *about 0.3* to *0.5* cent per kilowatt-hour. These values lie between hydro-electric costs and the fuel-plant costs, as shown in Table 7.

Because of the costs neglected, this will later prove to be an under-estimate of the cost for the near future. It will be necessary to examine further the simplifying assumptions made above.

4.5. We shall now try to estimate in more detail the probable future cost of nuclear power.[7] If we postulate a plant of reasonable size, say 100,000 kw., we can examine a breakdown of probable costs. Such an analysis is intended merely as an illustration. We have assumed here that the fuel costs will occur only as fixed charges on the original investment. We will then examine the remaining costs; the other fixed costs, and labor, maintenance, and miscellaneous materials. In a fairly arbitrary manner we will estimate all purification and reprocessing costs to be 0.1 cent per kw-hr.

The cost of all the equipment *except* the pile itself may be estimated from data on the cost of steam-electric plants. If we use the same basis as before, or $120 per kilowatt capacity and remember that we save the expense of a furnace, about 25 per cent of total plant up to the bus-bar, then we have for such a plant:

0.75 x $120 per kw. = $90 per kw.

It is much more difficult to estimate the cost of the pile with its fissile charge. While the cost of present-day piles is much higher, the author has estimated that a reasonably achievable goal for this cost is in the neighborhood of $100 per kw. Furthermore, a first approximation to this task has been given in a study entitled "Nuclear-Energy Potentialities" by Wagner and Hutcheson of the Westinghouse Electric Corporation released in August, 1946. They give two estimates to indicate the probable range: $60 per kw. and $120 per kw. respectively. Taking the latter, more conservative figure we get a total investment of about $210 per kw. of electric capacity. Then the fixed-charge cost per kilowatt-hour can be estimated by using the over-all fixed percentage developed in Section 4.3, about 12 per cent.

To the above fixed costs may be added an allowance for labor and maintenance similar to that given in Section 4.3 equal to about 0.09 cent

TABLE 5

BUS-BAR COSTS OF COAL-STEAM ELECTRIC PLANT
(Typical of Better Plant) 1944
Cents per kilowatt-hour

	Load Factor =0.5		Load Factor =1.0	
I. Direct Costs				
1. Fuel cost at mine ⌙0.12+transport & handling ⌙0.18	0.3		0.3	
2. Labor	0.05		0.05	
3. Maintenance & other supplies	0.04		0.04	
Subtotal		0.39		0.39
II. Fixed Costs				
1. Overhead, administrative and general	0.06		0.03	
2. Taxes (& franchise costs)	0.13		0.065	
3. Interest	0.08		0.04	
4. Depreciation (& reserves for obsolescence)	0.08		0.04	
5. Insurance	0.01		0.005	
Subtotal		0.36		0.18
Total cents/kw-hr.		→0.75		→0.57

Assumptions:
1. Plant investment =$120 per kw. of capacity,
2. Thermal efficiency =0.26=(1 lb. coal/kw-hr.),
3. Coal price =$6/ton delivered,
4. Fixed cost total =12% of plant investment,
5. Correction for "power factor" of 0.9 has been made.*

* Power factor is not the same quantity as load factor; a value between 0.8 and 0.9 is normal for plant power factor. See any text on technical electricity.

TABLE 6

COST OF POWER WITH DIFFERENT COAL PRICES
(cents per kilowatt-hour)

Coal Price	Load Factor=0.5	Load Factor=1.0
$ 4. per ton	⌙0.65	0.47
6. " "	0.75	0.57
8. " "	0.85	0.67
10. " "	0.95	0.77
12. " "	1.05	0.87

This table has been calculated using the same assumptions as Table 5.

TABLE 7

ROUGH COMPARISON OF POWER COSTS

	cents/kw-hr.
1. Hydro	0.05→0.4
2. Nuclear (first approx.)	0.3 →0.5
3. Coal-steam	0.4 →1.5

7. The author has assumed a greater degree of development than was assumed in the preparation of the Thomas report (*Scientific Information Transmitted to the United Nations Atomic Energy Commission by the United States Representative*, Vol. IV, "Nuclear Power," September 5, 1946, 6 pages). The latter report was based upon a modification of the existing Hanford installation and contained an estimated cost of 0.8 cents per kw-hr. at 100% load factor.

per kilowatt-hour. Total estimated nuclear power costs are shown in Table 8.

No great accuracy can be assigned to the values given. Probably ± 50 per cent is the best that should be claimed for these early figures. As more is learned and as more available information is released it should be continuously refined. It will be seen that a large part of the estimated cost is represented by the fixed charges on the investment in plant.

The costs projected above are estimates made in the beginning developmental period of new and rather complicated processes. Necessarily the solution of many technical problems is assumed here. These solutions will properly take time, one can estimate something like five years, optimistically, or longer.

For the more distant future it should be noted that almost one-half of the total cost is represented by fixed costs on the fissile materials. As this investment cost becomes less and less, owing to improvements in the synthesizing and separating processes, this item in the power cost will be reduced. Moreover, see footnotes under Section 2.6. It could be hoped that a rate of, say, 0.3 cent per kilowatt-hour might be achieved in, perhaps, ten to twenty years of further active development.

TABLE 8

NUCLEAR POWER COSTS
(near future, say, 5-10 years)
(cents per kilowatt-hour)

	Load Factor = 0.5	Load Factor = 1.0
I. Direct Costs:		
Labor, Maintenance,	0.09	0.09
Reprocessing Costs	0.10	0.10
II. Fixed Costs:		
Fissionable Materials in Pile	0.34	0.17
Auxiliaries & Secondary Machinery	0.24	0.12
Total	0.77	0.48

TABLE 9

Estimated Annual Demand for Energy, United States, 1940-1943

Category*	Amount
1. For Power Production (all forms)	340×10^6 kw. of heat energy
2. Nonindustrial Heating	200
3. Industrial Heating and Other	360
Total	900×10^6 kw.

* Power production for electric power plants, automobiles, and locomotives has been included. Retail deliveries of coal were used to estimate the nonindustrial heating.

Other Factors Affecting Feasibility of Plants

4.6. Other criteria of atomic energy plants beside cost also determine their feasibility. In the selection of a site for any power plant, the climate, transportation, and maintenance facilities are important considerations. For most ordinary plants the availability of good water supplies and firm foundations are extremely important. Atomic energy plants have similar problems and requirements. The particular problems will depend as much on the system that receives and converts the pile heat, the heat engine, as they will depend on the pile.

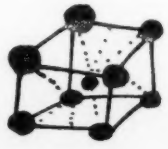
For instance, a good water supply would be of paramount importance in a pile, steam-turbine system but of negligible importance in a pile, gas-turbine system. While it would be futile to set down here the engineering requirements peculiar to the piles, one might mention such obvious necessities as freedom from earthquake shocks and floods. These criteria may rule out regions where such energy may, otherwise, be produced economically.

Furthermore, for many years the pile will require a high caliber of supervisory personnel. Remote regions are not likely to attract and keep the necessary ability.

Considerations of employee and community health and safety will continue to command attention until such plants are well established.

The anticipated power demand, the load factor, will help to determine the feasibility of a pile installation. The high original cost will weigh heavily against any installation to serve a sporadic demand.

The enormous convenience of handling such a concentrated fuel is very important. Localities remote from water power and cheap coal can be served with power. In aluminum manufacture, for instance, it might cost more to transport bauxite in certain cases to the power site than to buy the power itself. The emancipation from the problem of transporting fuels in bulk will argue strongly for the feasibility of many pile installations.



Finally, military and political expediency will also contribute strongly to such decisions.

4.7. There are, of course, other forms of demand for energy than the coal-steam example given in Section 4.4.

Rough estimates for the United States for 1940-1943 have been made [18, 19, 21], and are shown in Table 9.

About 1/6 or $53. \times 10^6$ kw. of the heat energy used for power production comes out in useful form. Of this useful energy about $23. \times 10^6$ kw. is generated in the form of electricity, ⅓ by hydro-electric plants and almost ⅔ by coal-burning, steam-electric plants [42]. This ⅔ fraction, or about 15×10^6 kw., a representative figure for, say, 1940-1944, equivalent to about 5×10^4 lbs. U per year, has served us as a useful form for comparison in Sections 4.4 and 4.5.

The importance of the fuel cost is large for both industrial and nonin-

dustrial heating. The high-temperature heat for certain industries (such as smelting and working metals) is not at present a feasible pile product. The upper temperature limits are defined by the properties of the materials of construction, such as strength and resistance to corrosion. However, lower-temperature process heat is a feasible pile product. In many cases this heat is gotten by industry at low cost as a by-product of power production. Heat as such is a difficult commodity to transport over any great distance. Nonindustrial heat sales (building and home heating) from piles would be limited to concentrated groups of consumers such as exist on Manhattan Island and buy heat (in the form of steam, N. Y. Steam Co.) from centarl heating plants. Nevertheless, large amounts of such heat are practicable outlets for pile energy and should be studied.

We have estimated the cost of power made by nuclear fission processes. We have in addition shown that important amounts of resources are available.

Hovever, these early estimates can only be valuable if they are continually revised with our growing fund of knowledge of nuclear engineering.

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THE HOUSE OF LORDS DEBATES INTERNATIONAL CONTROL

Edward A. Shils

Mr. Shils sends from London the following report of recent debates in the House of Lords on the international control of atomic energy. A summary of the last debate on the subject in the House of Lords on April 30, 1947, appeared in the BULLETIN Vol. 3, No. 7. Mr. Shils is an Associate Professor in the Committee on Social Thought at the University of Chicago and Reader at The London School of Economics.

A tone of grave depression, of helplessness and hopelessness pervaded the debate on the international control of the atomic bomb in the House of Lords on 18th February. The Lords had discussed the question last time in the Spring of 1947 on the initiative of the Archbishop of York and the matter was raised again this time by him. In a period of deepening apathy and distraction, the Archbishop has taken on himself the responsibility—almost the sole responsibility—for keeping the people of Great Britain and their Government alert to an international situation in which atomic bombs exist free of effective control.

Five members spoke, the Archbishop, Lord Cherwell, (Professor Lindemann), Lord Hankey, (for many years the Secretary of the Cabinet and a recent member of the Chatham House Atomic Energy Group), the Earl of Perth, and Lord Pakenham who replied on behalf of the Government (Pakenham is the Minister responsible for Germany, an Oxford don and a former collaborator with Lord Beveridge, in the latter's famous Report on Social Security.) In conformity with the qualifications of the participants, the debate was characterized by competence and dignity, and a high degree of freedom from irrelevant intrusions. Despite or because of these characteristics, the debate ended without positive proposals of a coherent sort.

The Archbishop of York Suggests Control Agency Without Russia

The Archbishop reviewed the recent proposals for loosening the impasse in the UN atomic energy discussion—the meeting of the heads of state—Truman, Attlee and Stalin—which the Parliamentary Atomic Energy Commission proposed early last year and which has recently been reaffirmed by Bertrand Russell, Raymond Blackburn and in a peculiar way by Mr. Churchill. He was sceptical as to whether Stalin was as uninformed about the atomic bomb issue as the proposal assumed but "if there is any possibility of there being a misunderstanding of the position by Marshal Stalin, it is worth almost anything to bring the full facts of the situation before him."

If that fails—in considering it, he did not take into account the consequences of the failure for relations between the Soviet Union and the West—the only other alternative of which the Archbishop could think was the formation of an international control agency without the Soviet Union. Unlike Bertrand Russell, who did not speak in the debate, but whose ideas were the principal object of discussion, the Archbishop was somewhat tentative and indecisive.

Apparently he had not thought the proposal out very clearly since on the one side he seemed to believe that those forming the international agency outside the Soviet Union would apply to themselves the same controls as the UN AEC reports proposed to apply to the whole world and that they would not make atomic bombs, singly or collectively; at the same time, he apparently expected the states which unite to have a great advantage over those who do not enter the agreement, an advantage which could only exist if they were to produce and stockpile atomic weapons on a large scale.

The Archbishop said: "It means that those who have entered into the pact will have tied their hands, whilst outside there are nations who are free to act whenever they wish to. On the other hand, it would mean that those who entered into the pact would possess overwhelming forces which they could use as a deterrent against any nation who proposed to use or had used the bombs," and left it at that.

The Earl of Perth too was sceptical of the efficacy of a meeting of the three heads of state because he very much doubted whether Stalin does not know what is involved. He also took the opportunity to reject the World Government solution, especially through the procedure now being associated with the name of Bertrand Russell who has counselled the use of force against the Soviet Union in order to bring it into a World Government.

Earl of Perth Advocates Ban on Use of Bombs

To the Earl of Perth, "the use of atomic energy to compel a reluctant Power to take part in a World Government is . . . strongly repugnant to the moral sense. Quite apart from that consideration, surely to force a country by threats to enter into a world arrangement would mean that that country would take every opportunity of sabotaging the world authority; and if it saw any favourable opportunity it would certainly endeavor to overthrow it."

For his own part, he desired that discussion in the Atomic Energy Commission should go on in the hope of finding a solution to the present disagreements and that a general convention should be drawn up to ban the use, although not the production, of atomic bombs. Even if the Soviet Union does not agree to the convention, other states should go ahead and sign it. If within a year—"it becomes clear that no general agreement . . . is practicable . . . then the nations that are ready to accept control and inspection should get together and conclude a separate convention, by which they would pledge themselves collectively and separately that if atomic weapons were used against any one of them, the others would retaliate by all the means which lay in their power, by the use of atomic weapons or otherwise."

In saying this, he gave a measure of the extent to which men of good will are being driven against their own intentions into proposals which if realized can only reduce the chances of reconciliation between the Soviet Union and the West, and thus make war more probable.

Lord Hankey Considers UNAEC Faces Impossible Task

The first two speakers had accepted unquestioningly the assumption that the proposals of the UN Atomic Energy Commission could have been effective had the political obstacles not prevented the establishment of the control scheme. Lord Hankey thought however that the Atomic Energy Commission had had an impossible task from the very beginning. The organization of peace is the hardest problem the human race has ever had to face, disarmament is the most difficult phase of peace making and "the toughest aspect of disarmament is the control of atomic energy . . . It involves both inspection which killed disarmament at Geneva, and sanctions which killed the League."

Not only was the task in itself almost insuperably difficult but the atmosphere of wrangling and suspicion in which the recent discussions have been carried on made its failure even more certain. But even more fundamentally, the end result would have been only "a very fictitious security . . . . An unreliable scheme is worse than no scheme because it gives all the advantages to the aggressor . . . the schemes upon which the Atomic Energy Commission have worked do not inspire much confidence in that respect."

Lord Hankey was distinctly critical of the assumption that bribery and corruption of the personnel of the international control body could be avoided. "Let us pause for a moment to consider the personnel who will be employed and the conditions in which they will carry out the work. They will come from many countries, a fact which always weakened loyalty and team work—for every nation will want to have a finger in the pie. They will also want to get the 'knowhow' of atomic energy, especially in the early days when the scheme is still on probation and the secret not yet divulged. Is it not certain that some countries will plant the organization with agents whose business it will be to discover all the secrets in order to forward the interests of their own countries rather than those of the United Nations?

"Then let us consider the inspectors of this varied personnel, planted out all over the world in different countries, for years at a time, in dull places, with the hateful task of ferreting out the evasion of the rules, whether it be in mine, laboratory, or factory, or on the communications between the two. Will they really be able to carry out their task? Will they be allowed to see more than their hosts want them to see? Some nations are past masters in gulling people. I suggest that the inspectors will often be gulled or lulled into inactivity and into keeping their eyes shut . . . . It seems to me that any nation would be mad to entrust its security to any scheme which has been produced up to the present time."

For these reasons Lord Hankey argued that the deliberations of the UN Atomic Energy Commission should be suspended.[1] At present the fruitlessness of its activities only lowers the prestige of the United Nations and aggravates the rancour and exasperation which the Great Powers feel towards each other. To suspend the UNAEC "would relieve the United Nations for a time of this intractable question and . . . give them time to build up solidarity and to establish confidence among the nations."

Lord Hankey would leave the bombs in the hands of the United States in whom he has more confidence than he has in the United Nations. He would concentrate Empire research resources on power development, or counter- and protective measures which he feels have greater possibilities than are ordinarily acknowledged. He would agree to the acceptance of an international prohibition of the use of atomic weapons in war if the research and development on them were not forbidden.

He would begin to try to use every last effort to reduce hatred and suspicion in the world and as a first step would declare a universal amnesty on war criminals. "I would like to leave it at that. It is not by fear, threats of counter measure and so forth, that the world can be won to decency and kindness, but by charity. Until a beginning is made in that direction, we shall never get either control of the atomic bomb or a reasonably stable peace."

1. Curiously enough Lord Hankey seems to believe that effective international control could be established at some later date, even though a large amount of mining and processing were to go on in the meanwhile. For reasons which he does not elaborate—related perhaps to the traditional higher civil servant's distrust of scientists, he says that "if and when the time comes again to take up the subject of control internationally, it should be dealt with by statesmen of the highest calibre with the best possible expert assistance, instead of being remitted to a separate expert commission."

Comments by Lord Cherwell On the Suggestions Offered

Lord Cherwell was inclined to be sympathetic with Lork Hankey's wish to suspend the UNAEC. He was however suspicious of the Earl of Perth's scheme for the establishment of an international agency without the Soviet Union since there are communists in the Governments and Civil Services and especially among scientists and engineers in the countries which would be called to participate in the scheme and "it would be difficult in many cases to make sure that they did not obtain all the information and knowledge which was being developed in the International Research Institution."

None of the speakers implied any criticism of the Government for its atomic energy policy. No criticism was directed either at any action of the American Government or its representatives in the United Nations Atomic Energy Commission. Indeed, on the contrary, the United States was highly praised for the generosity of the proposals made by Mr. Baruch, and its unwillingness to dispose of its bombs before the establishment of an effective control system was also fully approved.

Lord Pakenham Speaks for the Government

Lord Pakenham, who replied on behalf of the Government, reaffirmed this approval of "the generosity of the whole American attitude . . . . It is a very remarkable thing to find a country ready to throw away such an advantage providing agreement can be arrived at regarding terms." He underscored the differences between the majority view in the Commission and the Soviet attitude on the management versus inspection problem along familiar lines, and quite correctly; and stressed the difference between the Soviet and the majority postions on the periodic as contrasted with continuous character of the inspection procedures in the two schemes. The Russians have not defi-

nitely insisted that there be no continuous inspection of various operations, although, as in so many other matters, their position has been left in a state of ambiguity.

He stressed also the difference between the Russians' and the majority view on the composition of the inspection force. He said that although he did not wish "to give the impression that the Russians have insisted on the Russian plants being inspected by Russian inspectors entirely, they have not been ready to clarify their attitude in this matter, and until they do so, their proposals will not satisfy us." (The Russians in their reply to the British questions of last August quite definitely asserted that the personnel of the inspection force would be international in composition, and gave no indication whatever that they expected the various nationals in the inspecting force to be assigned to their own countries. It is true of course that they did not state explicitly, nor did they deny, that the installations in each country would be open to accredited inspectors regardless of nationality).

Lord Pakenham would not commit himself and the Government as to the hopelessness of the present negotiations in the Atomic Energy Commission. He admitted that the prospect of reducing the differences was definitely worse than a year ago. He recognized that the obstacles lay not simply in the atomic energy field itself, but in the whole range of attitudes on a wide variety of matters separating Russia from Britain and the United States.

He recognized, along with Lord Hankey and Lord Cherwell that "So long as that suspicion lasts, and while the general position remains as it is, these differences which I have set out . . . are not likely to be overcome in any one field, therefore I suggest to the House that we must not raise any great hopes in our minds nor in the minds of other people about agreement on atomic energy, unless and until we make progress toward reconciliation with Russia generally."

At the same time Lord Pakenham doubted "if most members of Your Lordships' House studying these differences on paper would conclude from them that there is a gulf between Russia and the rest of the world on this subject which cannot be bridged without the grave surrender of vital principles . . . Those members of Your Lordship's House who have discharged great responsibilities, have known of occasions where larger differences were overcome by diplomacy and negotiation."

From these statements one would be led to believe that some specific measures for overcoming the present tension would be under consideration by the British Government, given their acknowledgement of its importance and gravity. However, as regards future steps on the part of the Government, Lord Pakenham declared only that Great Britain would continue to participate in the Atomic Energy Commission and would "continue to try and extract advantage from continued discussions," and, "the Government feels that some limit must be set to affairs of this kind, and if we find all advance definitely and persistently resisted, we shall have to reconsider our whole attitude to the problem of atomic energy." There was no indication that the reconsideration was already underway.

Bewilderment and Discouragement Paralyze Official Thinking

The Debate thus ended as it had begun, in an atmosphere of directionless gloom. It showed once more that because of the extraordinary difficulty of the situation and the unwillingness to do anything that might affront the United States, (especially on a matter which is less urgent than Britain's economic needs), the British Government has no independently developed line of policy on atomic energy. Even on the question of the veto on sanctions which created such an obstacle or at least such a pretext for Russian obstruction in the early phases of the discussions in the Commission, and on which the Dominions' representatives had taken a clear line between the Russian and American position, no speaker either inside or outside the Government raised his voice.

This paralysis of thought on the atomic energy question in the British Government allows its spokesmen to stress on the one hand the necessity of a general reconciliation with the Russians and prompts one of the elder statesmen of the country to insist that only in an atmosphere of more general trust and confidence can the dangers of atomic war be avoided and it causes them to do this without making any specific suggestion or attempting to think through the implications of their conciliatory position.

Meanwhile, other Government spokesmen, discussing other aspects of relations with the Soviet Union, speak in the same challenging, upbraiding way—indeed with almost equal acrimony, although naturally less crudely—in which the publicists and politicians of the Soviet Union speak about the West.

Lord Pakenham stressing the need for general reconciliation can offer as a concrete measure for effecting this reconciliation only the fact that he speaks "with all humility as one who prays twice a day for Russia, and . . . [is] sure that the Most Reverend Primate would agree that there is no country in the world that so badly needs our prayers."

Lord Hankey, who also recognizes with the utmost clarity the necessity for general reconciliation with the Russians as a condition of preventing a war with atomic weapons, and who devoted a substantial part of his speech to an exposition of the official Soviet doctrine of the inevitability of conflict between the Soviet Union and the West, can offer as a concrete proposal, only the declaration of a universal amnesty for all war criminals.

In other words, to reconcile the Soviet Union with the West, Lord Hankey recommends a discontinuance of the trials and prosecutions, on which the Soviet Union is already so suspicious of the desire of the Western powers to treat indulgently those who wrought such destruction against the Soviet Union and to rehabilitate the Fascist enemies of their country.

Debate Reflects Insecurity Of British Position

The Debate in the House of Lords was conducted by some of the best minds of this country, by men with long political experience, and long and distinguished careers of responsibility for the guidance of public affairs. Yet the loss of self-confidence of the leaders of this country in their relations with the United States and the Soviet Union and their feeling of bewilderment are reflected as accurately here as anywhere. They recognize the fatal urgency of the problem; some of them even recognize that the problem must be solved as part of a general over-all solution of the present disorder. But none has felt impelled to think the matter through more concretely and more differentiatedly, and to try to estimate some of the conditions under which the monstrously complicated task of bringing Russian suspicion within the bounds normal to international relations could be achieved.

UNITED NATIONS ATOMIC ENERGY NEWS

Peter Kihss

Mr. Kihss, the representative of the NEW YORK HERALD TRIBUNE at Lake Success, reports negotiations on atomic energy control for the BULLETIN.

Soviet views on inspection as the chief world atomic control were sharply challenged during February United Nations debates. Disclosing some of the long-secret 1946 debates on technological problems, Dr. H. R. Wei, of China, said the then Soviet scientific expert, Semen P. Alexandrov, had agreed "managerial control" was needed to guard against diversion of materials from isotope separation plants.

February 2. With Vassily A. Tarasenko, of the Soviet Ukraine, taking over as chairman, the control committee held an informal session to discuss composition of a world control agency.

The Working Committee Re-studies Soviet Proposals

February 5. The working committee continued re-study of Soviet control proposals. Andrei A. Gromyko, of the USSR, asked if the United Kingdom, United States, Syria, Canada and China, when they spoke of linking outlawry of atomic weapons and establishment of controls, wished "to submit a formal proposal, the tenor of which would be that a convention for the prohibition of atomic weapons should be concluded, but that it should not be brought into force until the convention on control has been concluded."

The suggestion had already been refused by Russia, and so was "academic," Faris El Khouri, of Syria, replied. Dr. H. R. Wei, of China, and Richard T. G. Miles, of the United Kingdom, said the suggestion had represented a desire for agreement. Mr. Gromyko replied he knew of no decision by the majority in favor of two separate conventions, and declared "we are remaining on the same spot."

The committee then took up the fifth Soviet proposal, which would provide international personnel for a control commission empowered to carry out periodic inspection of mining and production facilities. Mr. Gromyko said: "We understand the word 'periodically' to mean that inspection shall not be a continuous process, but that it shall be carried out at definite intervals . . . The intervals may be varied by the international control commission . . . One cannot have a continuous inspection. In this case, one might consider it as a continuous supervision or as a continuous management, but it would not be inspection, because inspection means the checking of facilities at given intervals."

Francois de Rose, of France, asked whether the Soviet-envisaged agency could send inspectors into any participating country without first obtaining that nation's agreement. "The notions of periodical inspection and effective control are contradictory," he went on. Inspection includes (1) a check of books on past activity, (2) a check on materials to see whether they jibe with the books. But books might be juggled, and he cited several examples of difficulty in materials checks:

1. In mines, an inspector might be told a stockpile contains 5,000 or 10,000 tons, but the material can't be weighed right then and there and he couldn't actually verify exact content. Part of the stockpile, residue and refuse might have been transported elsewhere, and could not be accurately checked. No government or private enterprise would run such risks in mining gold or precious metals, Mr. de Rose said.

2. In an isotope separation plant, the inspector could not tell from the books the actual production tempo in a gaseous diffusion process, where thousands of successive operations occur. Even in clean-ups or shut-downs, individual weighing of all the materials in process would lead to errors, and "such interference on the part of the inspector will certainly be inadmissible."

3. In reactors, the very nature of a dangerous radioactive process would prevent access to material during processing. So Mr. de Rose contended inspection in reactors and isotope separation plants would be insufficient by itself.

Mr. Osborn and Mr. Tarasenko Make Statements

February 7. In a WCBS broadcast interview, Frederick H. Osborn, American delegate, said that "after two years of patient and sincere negotiations, we are no nearer agreement than when we first started out."

Mr. Osborn asserted any form of national operation with control simply by international inspection "will eventually break down in the face of those bureaucracies that would be charged with development and constantly prodded by the military who would want atomic bombs."

"As long as some two or three hundred million people, controlling large resources in the world's largest land mass, are shut off from all communication with the world, and the rest of the world has little knowledge of what's going on within their borders—as is the case with the Soviet Union—there can be no sense of security or a mutual confidence among nations," Mr. Osborn said.

Mr. Tarasenko told the *New York Herald Tribune* that Soviet proposals offer "a real basis for agreement." International accord, he said, "may be reached under conditions when the United States and countries supporting its position give up their insistence on a number of provisions which do not follow from establishment of the control of atomic energy."

On the same day, the World Health Organization interim commission ended its two-week fifth session in Geneva. Agreeing that American distribution of radioisotopes was of major interest to W. H. O., the agency decided to appoint an official at its New York headquarters to act as

designated representative for countries not having a scientific attaché in the United States.

February 16. Working committee heard Dr. Wei propose de-classifying the records of the private 1946 discussions and expert testimony on technological problems.[1] Then, he said, people would see how delegates came to recommend management as the necessary control for dangerous facilities. "At first," he recalled, "many of the representatives did not have strong convictions and most of them were inclined to prefer inspection to management."

Dr. Wei Discusses Management and Inspection

Since the Soviet now maintains inspection is a sufficient control, Dr. Wei said it should prove the expected difficulties either did not exist or could be countered satisfactorily by inspection. "We are all aware of the possibility of new technological developments," he said. "Some phases of atomic technology are no longer the monopoly of one single nation."

As problems seen in the 1946 talks which indicated inspection alone would be ineffective, Dr. Wei listed:

1. Danger due to diversion of enriched nuclear fuel. "An appreciable amount of enriched nuclear fuel could be carried away in the back pocket of a workman." Since nuclear fuel can be made into bombs, "it is necessary to know where all of it is."

2. Difficulties of material balancing. "The material balance of chemical processes involving uranium compounds over a short period are uncertain, and may be either negative or positive. A year's unaccountable loss might involve a considerable quantity of material with large fluctuations, and its significance might not be determined at once, even though extreme precautions were taken."

3. Other possible dangerous diversions. "With the size and complexity of the present gaseous diffusion plant, material could be easily withdrawn at a number of places with little risk of immediate detection by any inspection agency." Diversions could also be concealed by unreported improvements in technique, by faulty isotope analysis, or, in reactors, during preparation of ingots by substitution of materials and removal of slugs.

Mr. Gromyko Complains of U.S. Attitude

Mr. Gromyko complained that the United States was not taking part in discussions. Mr. Osborn admitted this and asserted: "We are only going over old ground which has been thoroughly and completely discussed." Mr. Gromyko retorted that asking questions was a process which might continue indefinitely. The "more fruitful way," he said, would be to consider and adopt Soviet control proposals, elaborating them further. The Soviet, he said, never claimed its proposals would exhaust all types of controls, but rather were "basic lines."

"If we start from the end by taking up the details of technological process, not being familiar with these details of technological process, or at least having a very vague knowledge thereof, I do not think that we shall move forward with much success," Mr. Gromyko said. He held the 1946 scientific and technological reports did not include concrete data from analyses of production processes, "for the reason that these scientific experts did not have at their disposal any atomic material." The experts' deductions, Mr. Gromyko said, "had a conditional character," and were based on hypothetical arguments.

Taking up the earlier French questions, Mr. Gromyko said governments "must have the right to object in separate cases on personal grounds" to entry of certain inspectors. To Mr. Osborn, he said that if a new statement was something that would agree with certain American proposals, "then he certainly has not heard anything new, inasmuch as this was not our aim. Our aim was to prove that the Soviet Union proposals were reasonable and necessary and that they could be taken as a basis for the establishment of control over atomic energy." Mr. Gromyko added: "Actually there has been nothing new forthcoming from the United States delegation since the first declaration of Mr. Baruch."

The committee then took up the sixth and seventh Soviet points, setting forth activities and rights of the projected control commission. Dr. John D. Babbitt, of Canada, said the powers provided for special investigations "only when there was suspicion—and strong suspicion—that a nation possessed the bomb or was actually engaged in manufacturing one," and that otherwise powers were limited to recommendations to nations or the Security Council.

Mr. de Rose asked if investigations could be based on suspected violations of the control convention, as well as the prohibition pact. Mr. Gromyko said they could check violations of both. Mr. Miles asked whether the Soviet envisioned "mandatory rules" on stockpiling, production, etc. Mr. Gromyko said recommendations should not have compulsory force, but if experience showed a control convention should be amended to include obligatory rules, then such rules should be adopted.

Isotope Separation Plants Discussed

Dr. Wei dipped into the secret records of the Dec. 2, 1946 control committee discussion of diversion from isotope separation plants. These listed the Soviet expert, Dr. Alexandrov, as saying "that he would be satisfied if the following points were included in the document: that inasmuch as isotope separation plants produced dangerous concentrated material, the control authority should pay particular attention to this stage of production; that, inasmuch as methods of production in isotope separation plants had moved faster than the development of scientific control of the plants, the committee was not in a position to indicate other methods of control which might be possible. He suggested that scientists of various countries might be asked to work on improving methods of technical and scientific control, but, until those methods were worked out, one would be forced to depend on managerial control."

(In private talks, commission members said Dr. Alexandrov had helped draft the first report's definition of "management," and was using the term in the sense of international operation. But the Soviet delegation said he was simply thinking of rules by which national management would take place).

From the same records, Dr. Wei quoted Professor Ignace Zlotowski, of Poland, as believing a statement should be added "saying that isotope separation plants had to be under managerial operation by the controlling agency so long as one based his conclusions on present knowledge," although if plants could be safely designed, it would be better to have national management.

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1. Announcement was made on March 9, that Dr. Wei's proposal had been adopted. A summary of significant parts of this testimony will appear in the next issue.

Dr. Wei observed that if these technological problems still existed, they explained what dominated delegates' worries. Mr. Gromyko simply commented: "It is difficult to remove the worries if they are rooted very deeply."

Truman and Marshall Report to Congress on UN

February 20. President Truman and Secretary of State George C. Marshall, in a report to Congress on the UN in 1947, listed the atomic effort among "disappointments." The report said:

"It cannot be said that the deliberations in the Atomic Energy Commission have widened to any appreciable extent the area of agreement that existed two years ago. While it is generally agreed that there should be an international agency to carry out some system of atomic energy control, that atomic weapons should be eliminated from national armaments and that there should be some system of international inspection, such areas of agreement are larger in appearance than in fact.

"Discussions on the basic issues have disclosed that the Soviet Union and Poland have a completely different conception of the most important elements considered by the United States and other members of the majority as essential to an effective system for the international control of atomic energy."

Chief differences were listed as (1) ownership of source material, which the majority believes should become international after mining; (2) ownership, management and operation of dangerous facilities, which the majority believes should be internationalized; (3) research, in which the majority believes dangerous activity should be exclusively international; (4) inspection, with the majority favoring comprehensive measures, particularly where there might be clandestine activities; (5) elimination of atomic weapons from national armaments, which the majority believes should take place only when safeguards are in effective operation; and (6) enforcement, in which the majority wants the veto eliminated.

Gromyko Urges Agreement on Basic Principles

February 27. The working committee heard Mr. Gromyko complain that "we are moving very slowly," and urge delegates to "try, if it is possible and if it is acceptable, to agree on the basic principles involved." Mr. Miles said the questioning had revealed serious doubts whether the Soviet plan would give an agency "real powers, real teeth, to control the misuse of atomic energy by monopolistic capitalism, no less than by dictatorships run amuck, or by any other sort of madness in the world."

"The first thing," Mr. Miles added, "is to have an effective system of detection, and we feel very strongly that such a system of detection must be continuous and automatic. It cannot wait on this clue or that clue as to the existence of a possible violation. The essence of this matter is to insure that a misuse has not developed before it is too late."

General Agreement Exists on Research Functions

Debate turned to the eighth and final Soviet point, which would allow nations unrestricted research for peaceful purposes, and empower the international agency to carry on similar research and to insure exchange of information. Mr. Gromyko said the agency could investigate if it had information that research was using dangerous quantities of nuclear fuel, as well as reports on production of illicit atomic weapons.

Mr. de Rose, Dr. Wei and Mr. Miles agreed there was considerable agreement on research functions for the international agency. Mr. de Rose recorded a reservation that the international body should itself "undertake research on atomic weapons, so that, should an infraction be committed by a party to the convention, the international community would be armed in this matter." Mr. Gromyko reiterated the Soviet view that a ban on atomic weapons meant "no scientific research whatsoever in the field of atomic weapons should be undertaken."

With re-study of the Soviet plan virtually completed, Mr. Miles said the Soviet control proposals were "a positive contribution," but he deplored Soviet resistance to any revision of viewpoint. The British delegate suggested future meetings might go back over the ground "to find the basis of agreement on any of those points on which we have had rather sharp differences."

NEW STRATEGIC CONCEPT OF DEFENSE OF U.S.

SURVIVAL IN THE AIR AGE, a Report by the President's Air Policy Commission, Thomas K. Finletter, chairman, was published on January 1. A digest of the new strategy of defense appears below.

We believe that it is the overwhelming view of those most qualified to know that the country must have a new strategic concept for its defense and that the core of this concept is air power.

We can no longer follow our traditional procedure of relying entirely on the Navy as our force in being in peacetime. Protected by the Navy, and by the land, sea, and air forces of our Allies, we were able to convert our great industrial machine and our manpower for war after war had begun.

This will not be the case in a future war. Our surface fleet can have and does have a supremacy of the seas which is so nearly complete that it can guarantee the safety of our cities and our factories from surface attack by water. The only immediate naval danger—and against this we must always be on guard—is the development of new submarine techniques on the part of a possible enemy.

Chance of Air Attack Requires New Strategy

But there is a new element through which this country may be attacked—the air. And the new weapons which can be delivered through the air make it vital that we protect ourselves from attack by way of this new element. This means an air force in being, strong, well equipped and modern, not only capable of meeting the attack when it comes but, even more important, capable of dealing a crushing counteroffensive blow on the aggressor.

Atomic weapons will not long remain our monopoly. Biological warfare might become a serious factor in another war and we must be alert to every aspect of defense against this kind of attack. The preplacement of atomic and biological weapons may soon become a major military problem.

This means that the traditional peacetime strategy of the United States must be changed radically. We must count on our homeland becoming increasingly vulnerable as the weapons increase in destructiveness and the means of delivering them are improved. And we must assume that if future aggressors will

have learned anything from World Wars I and II it will be that they must never let United States industrial power get underway; they must destroy it at the outset if they are to win.

When must we assume that other nations will have atomic or other comparable weapons and missiles to deliver such weapons against the United States homeland? How long will it take us to build up the force which we must have when other nations have these weapons and can deliver them against us? What force do we need immediately?

Assumptions on Which Defense Should Be Based

We should make our strategic plans for the defense of the United States on the following assumptions:

(1) It is impossible to know certainly when other nations will have atomic weapons, but it is proper to assume that other nations are not now producing such weapons in quantity.

(2) It is known that other nations are working diligently on the problem of atomc energy.

(3) If an effective system for reviews of the strategic situation and for the adapting of our procurement and research and development policies to our strategic needs is established, it would be safe to assume, in making our plans for the next 2 years, that possibly hostile powers will not be producing atomic weapons in substantial quantities before the end of 1952.

(4) It would be an unreasonable risk, and therefore, a reckless course, to rely on other nations not having atomic weapons in quantity by the end of 1952 .

(5) It would be an unreasonable risk to assume that this country will surely have warning of the manufacture of atomic weapons by others.

Biological weapons are undoubtedly being studied in all parts of the world. They differ from atomic and conventional weapons in that their most destructive effect is not on impact but by slow or epidemic spreading. They may be delivered by the air, or by preplacement by enemy agents. So delivered or placed they would create great damage to humans, animals, and crops. Our plans to anticipate and prevent such sabotage, insofar as this can be done, must be intensified.

It is certain that conventional weapons will be developed in the next few years so that their destructive power will be even greater than in World War II. Nevertheless, it is the mass-destruction weapons which radically change the strategic needs of the United States. An enemy can inflict enormous damage with the mass-destruction weapons even if he does not have air superiority, thus changing all the rules and requiring a different strategy by a nation which may be attacked.

The only attacks of importance which could now be made on the United States mainland would be by air, by the preplacement of weapons by the enemy agents, or by attack from submarines. We do not believe that such attacks now, equipped as they would be (we may assume) only with nonatomic weapons, could destroy our ability to retaliate and to gear ourselves up for an all-out counterattack on the enemy.

An attack on the United States by piloted aircraft in the immediate future would not give an enemy air superiority over our mainland; although it could inflict serious damage on our industry and our cities before our defenses could be developed.

Nor is it possible for an enemy now to deliver an assault on the United States mainland with guided missiles which would be so serious as to prevent our preparing to win after the fighting started. The United States in the opinion of this Commission, could now undergo the ordeal of an attack delivered by the presently available piloted or unpiloted aircraft and by sabotage, and under the heavy handicaps which such an atack could create, still be able to follow our traditional course of building up our war machine after war has begun.

The Chances of Attack by New Methods of Delivery

We see nothing in the present situation to justify fear that the development of supersonic transpolar or transoceanic piloted aircraft or guided missiles by any possible enemy will threaten our air supremacy and our homeland within the immediate future. Evidence has been given before this Commission that such supersonic aircraft will not be developed into the mass-production stage for several years and that long-range supersonic missiles will not be available in operational form for from 10 to 25 years. Evidence has also been given before this Commission that subsonic guided missiles with a 5,000-mile range and capable of beng directed toward a sizable target, such as a city, can be developed into the mass-production stage within 5 years; but these subsonic missiles would be subject to a high rate of interception. This is a fast-moving branch of science, and any estimate may be upset by some unforeseen development or by some unforeseen obstacle.

It is probable that other nations will develop atomic weapons before they develop supersonic bombers in quantity with a striking range of 5,000 miles, or supersonic, accurate, guided missiles with a 5,000-mile range. Nevertheless it would be unwise to assume, in the planning of our defense establishment, that other nations will not have the planes and missiles capable of delivering a sustained attack on the United States mainland by the same date we have assumed they may have atomic weapons in quantity—namely, by the end of 1952. The United States must press most energetically and immediately its basic and applied research and development programs in aerodynamics, power plants, electronics, and related fields with a view toward the development at the earliest possible date of the most effective piloted aircraft and guided missiles and the defenses against them.

Planning of Defense Should Be Divided into Two Phases

The conclusions of the Commission thus fix the taget date by which we should have an air arm in being capable of dealing with a possible atomic attack on this country at January 1, 1953. For convenience we will refer to this date as A-day.

We believe that A-day divides the future into two clear phases for strategic purposes. We call this Phase I. The second phase is that which will exist on and after A-day. We call this Phase II.

What we need during this Phase is an integrated Military Establishment, (1) capable of an atomic attack, (2) stronger in air power than that of any other country, and (3) capable of sustained and powerful air counteroffensive, either directly or by the way of intermediate bases.

The strategy for Phase II is determined largely by the kind of attack which is likely to be made if war occurs during that phase. Our conclusions are as follows:

1. We must assume, in making our plans, that there will be a direct attack on the United States mainland in any major war in which the United States will become engaged on and after January 1, 1953.

2. It must be assumed that there may be no warning of the attack, that the force we will bring into being by the end of 1952 will be the force which will have to handle the attack.

3. An attack by an enemy equipped with atomic weapons would be of a violence which is difficult for us to imagine. The first bombardment assault by an enemy equipped with mass destruction weapons would probably have as its objective the destruction of our capacity for resistance and counterattack. No one who appeared before us has suggested that we could turn back completely such an attack.

In neither phase can we have in being a counteroffensive force capable of winning this war outright in the first counterblow. What we must have and can support is a reasonably strong defensive establishment to minimize the enemy's blow, but above all a counteroffensive air force in being which will be so powerful that if an aggressor does attack, we will be able to retaliate with the utmost violence and to seize and hold the advanced positions from which we can divert the destruction from our homeland to his.